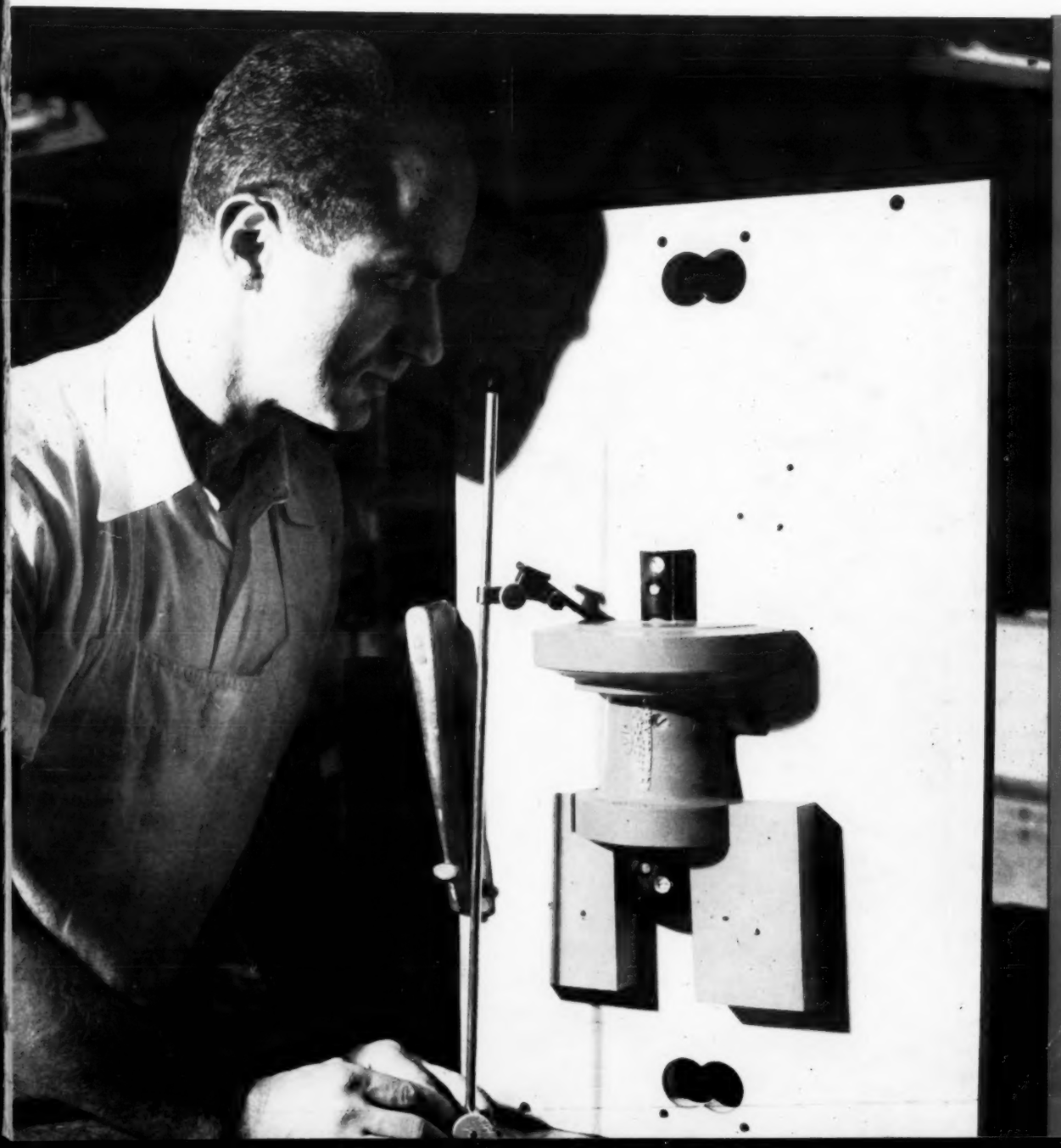
modern castings

JULY, 1958



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Leased foundry production equipment may save capital, increase profits

Saving Lives ..... p 21
Safety contest of Twin City Chapter promotes interest in safety program

Saving Time ..... p 22
Epoxy resin technique duplicates wood pattern in as low as 3.75 man-hours

Saving Space ..... p 24
Castings cool on railroad cars and free floor space for productive use

Saving Through Training p 28
Student calls training received at typical AFS T&RI course "a bargain"

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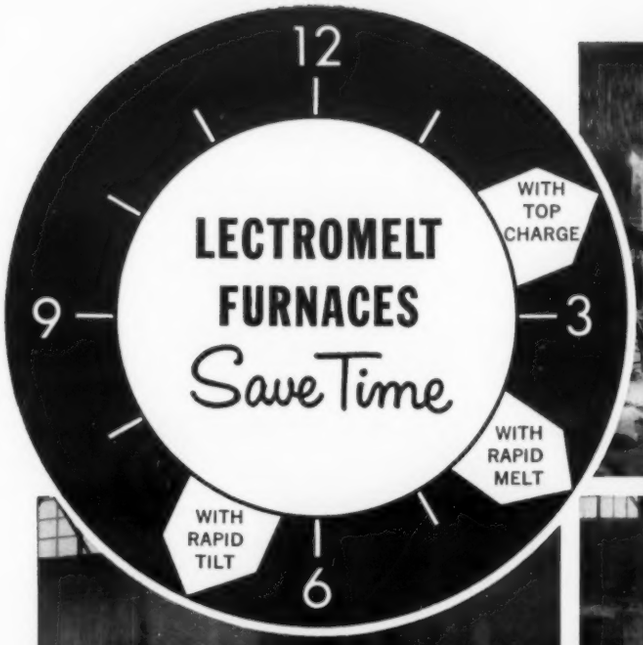
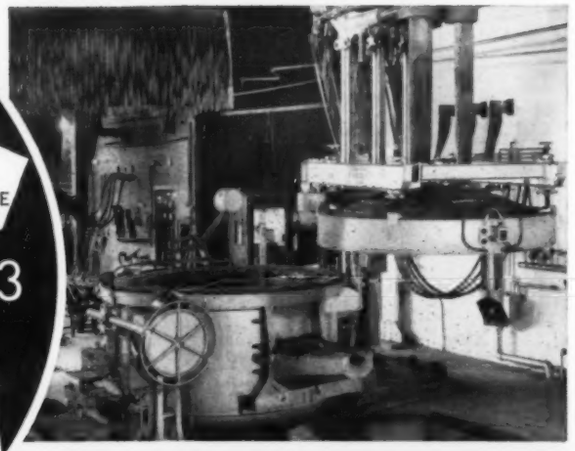
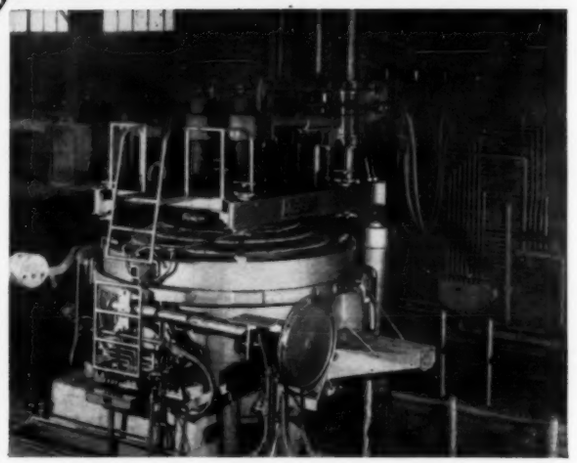
Final report on the technical program of the 1958 AFS Castings Congress







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TOP CHARGING provides smooth, fast turn-around in furnace operation—less downtime between heats and less heat loss. Linings and electrodes last longer.

HIGH POWER INPUT allows rapid metal melting. Lectromelt makes this possible with large transformers and leads, more efficient cooling and heavier furnace construction.

RAPID TILTING is accomplished smoothly and safely. Mechanism is accurate, strong and side-mounted—located out from under, where it won't get clogged by spillage.

Catalog 10 describes Lectromelt Furnaces. For a copy, write Lectromelt Furnace Division, McGraw-Edison Company, 316 32nd Street, Pittsburgh 30, Pennsylvania.

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Circle No. 241, Page 7-8

future meetings and exhibits

JULY

21 . . AFS T&RI Trustees, *Annual Meeting*. Union League Club, Chicago.

21-22 . . AFS Finance Committee, *Annual Meeting*. Union League Club, Chicago.

AUGUST

7 . . AFS Executive Committee, *Special Meeting*. Dearborn Inn, Dearborn, Mich.

7-8 . . AFS Board of Directors, *Annual Meeting*. Dearborn Inn, Dearborn, Mich.

18-22 . . Illinois State Board of Vocational Education, *Foundry Workshop*. University of Illinois, Urbana, Ill. *Co-Sponsored by AFS*.

SEPTEMBER

10-11 . . American Die Casting Institute, *Annual Meeting*. Edgewater Beach Hotel, Chicago.

22-23 . . Steel Founders' Society of America, *Fall Meeting*. The Homestead, Hot Springs, Va.

22-24 . . Material Handling Institute, *Joint Industry Fall Meeting*. The Greenbrier, White Sulphur Springs, W. Va.

23-26 . . Association of Iron and Steel Engineers, *Exposition*. Public Auditorium, Cleveland.

29-Oct. 3 . . Association Technique de Fonderie de Belgique, *25th International Foundry Congress*. Brussels and Liege, Belgium.

OCTOBER

6-8 . . National Association of Corrosion Engineers, *Annual Meeting, Northeast Regional Division*. Somerset Hotel, Boston.

8-10 . . Gray Iron Founders' Society, *Annual Meeting*. Sheraton Park Hotel, Washington, D. C.

13-18 . . National Industrial Sand Association, *Semi-annual Meeting*. The Greenbrier, White Sulphur Springs, W. Va.

15-16 . . AFS *Michigan Regional Foundry Conference*. University of Michigan, Ann Arbor, Mich.

16-17 . . AFS *All Canadian Regional Foundry Conference*. Royal Connaught Hotel, Hamilton, Ont.

16-18 . . Foundry Equipment Manufacturers' Association, *Annual Meeting*. The Greenbrier, White Sulphur Springs, W. Va.

17-18 . . AFS *New England Regional Foundry Conference*. Massachusetts Institute of Technology, Cambridge, Mass.

22-23 . . National Management Association, Annual Meeting. Statler-Hilton Hotel, Los Angeles.

27-31 . . American Society for Metals, *National Metals Exposition & Congress*. Public Auditorium, Cleveland.

30-31 . . AFS *Purdue Metal Castings Conference*. Purdue University. West Lafayette, Ind.

31-Nov. 1 . . AFS *Northwest Regional Foundry Conference*. Multnomah Hotel, Portland, Ore.

NOVEMBER

10-12 . . Steel Founders' Society of America, *13th Technical & Operating Conference*. Carter Hotel, Cleveland.

20-21 . . National Foundry Association, *Annual Meeting*. Drake Hotel, Chicago.

DECEMBER

3-5 . . American Institute of Mining, Metallurgical & Petroleum Engineers, *Electric Furnace Steel Conference*. Statler Hotel, Detroit.

9 . . Material Handling Institute, *Annual Meeting*. New York.

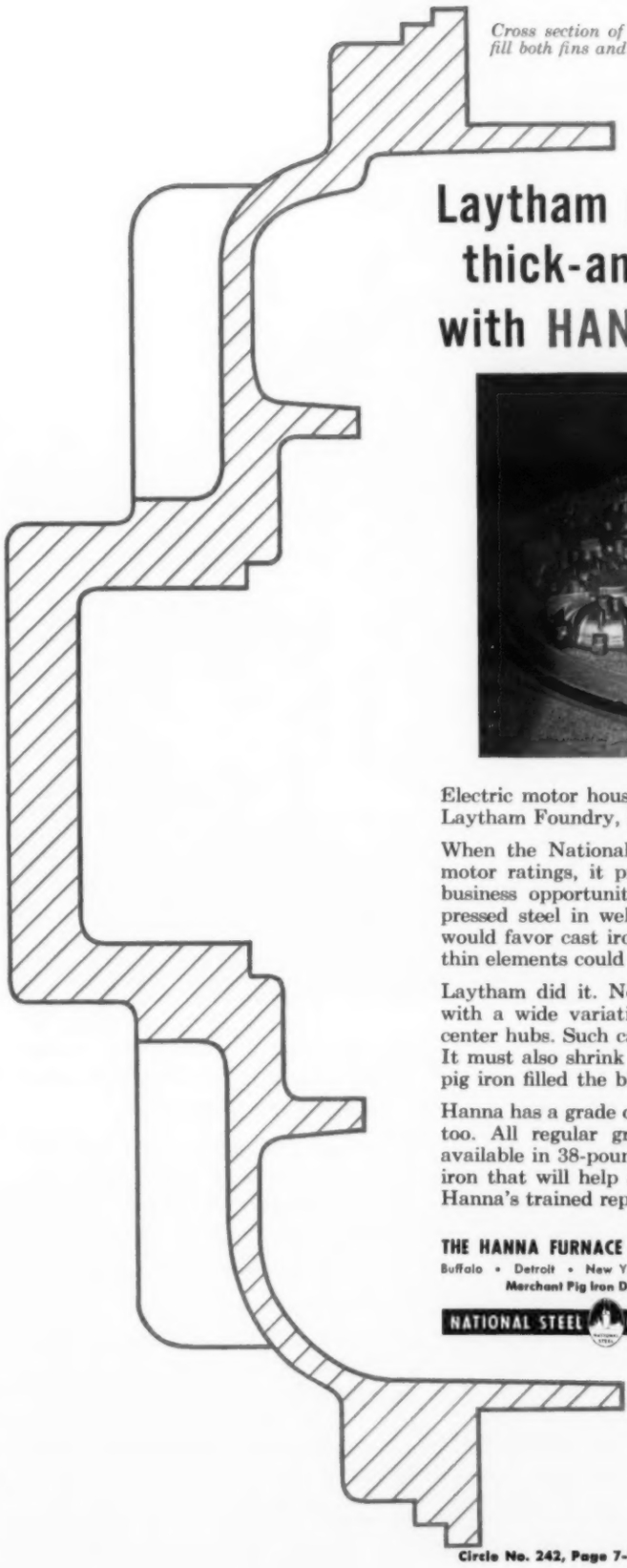
New Wear-Resistant Iron Uses Aluminum Addition

■ A new family of cast iron alloy promises to provide an engineering material with unusual wear-resistance. The Meehanite Metal Corp., New Rochelle, N. Y., developed the alloys which depend on aluminum and manganese to harden the iron to high levels.

The addition of aluminum produces a new material, "Almanite," said to maintain the advantage of hardness without detriment to toughness. The microstructure shows a eutectic carbide network in a pearlitic-bainite matrix. In certain types of the material chromium is also used as an additional alloying element, which the manufacturer claims provides glass-hard carbides of exceptional wear-resistant ability.

Two major classes are being produced. Typical properties for one class are:

Continued on page 2



Cross section of motor cover casting shows how iron must fill both fins and center hub to solve heat diffusion problem.

Laytham casts complex thick-and-thin motor housings with HANNA PIG IRON

Electric motor housings today are a large volume item produced by Laytham Foundry, Inc., Paterson, New Jersey.

When the National Electrical Manufacturers Association raised its motor ratings, it presented Laytham with a challenge—and a new business opportunity. Where many former housings were made of pressed steel in welded sections, the need for greater heat diffusion would favor cast iron, providing the proper combination of thick and thin elements could be achieved.

Laytham did it. Now they regularly produce motor frame castings with a wide variation in section thickness from thin fins to heavy center hubs. Such castings require iron with a high degree of fluidity. It must also shrink evenly and be free of porosity. Hanna Malleable pig iron filled the bill perfectly.

Hanna has a grade of high-quality pig iron to meet your requirements, too. All regular grades, plus HannaTite and Hanna Silvery, are available in 38-pound pigs and the smaller HannaTen ingots. For pig iron that will help solve your metallurgical problems, call on one of Hanna's trained representatives.

THE HANNA FURNACE CORPORATION
Buffalo • Detroit • New York • Philadelphia
Merchant Pig Iron Division of
NATIONAL STEEL CORPORATION

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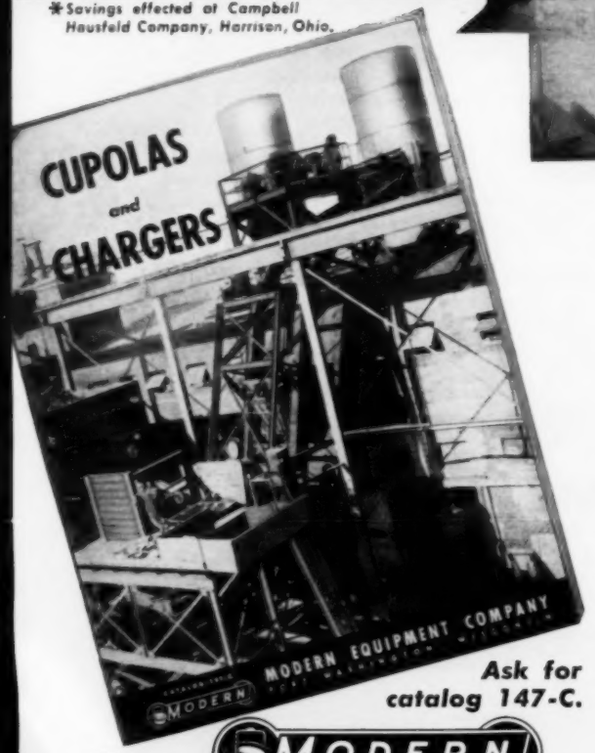
*SAVED

MEN...
COKE...
METAL...

*Savings effected at Campbell Haustfeld Company, Harrison, Ohio.



A good start on foundry mechanization — and lowered tonnage costs — frequently involves the removal of an obsolete elevator and the installation of pit, scale and skip charger.

Automatic cycling, between pit and cupola, saves the time that otherwise is wasted in traveling up and down. While one charge is on its way up another charge is made up. Time is made available, too, for over-all, more accurate metallurgical control. Coke costs come down. Quality of the castings goes up. Sales increase and the cycle repeats.

As a good starting place in your own, cost-cutting and sales building program ask for charger catalog 147-C. The catalog shows a size and type of charger for every foundry need.

MODERN EQUIPMENT CO., Dept. M-1, Port Washington, Wis.

- ☐ Catalog 147-C on charging and melting . . .
- ☐ Catalog 150 on cranes and monorail systems . . .
- ☐ Catalog P-152-A on ladles and pouring . . .

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Ask for catalog 147-C.

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Continued from page 1

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2) Impact Strength, 1.2-in. bar—56 ft lb.
3) Transverse strength, 1.2-in. bar, 12-in. center—4800 psi.
4) Impact on 1.2-in. bar—over 120 ft lb.

Officials state that the material can be produced to be fully machinable and, when heat-treated, to offer magnetic properties. Experiments are now being conducted to determine the full characteristics of this new material.

■ For more information about this new development, circle No. B, page 7-8.

COVER PHOTO:
Courtesy of Cooper Alloy Corp., Hillside, N. J.

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vol. 34, no. 1

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COMING ATTRACTION:

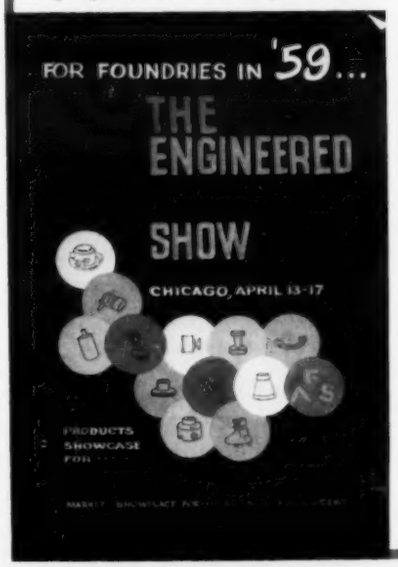
2d Engineered Castings Show

Yes, already it's time to start thinking and planning for the 2d Engineered Castings Show combined with the 63d Castings Congress in Chicago, April 13-17, 1959. Once again metalcasting producers will stage an exhibit to demonstrate their capabilities to design engineers and castings buyers.

Present indications are that close to 200 alert foundries and pattern shops will occupy 25,000 sq ft of exhibit area in the Sherman Hotel. These companies will prove the ability of the versatile casting processes to solve the problems of design engineers and supply the buying needs in all industries.

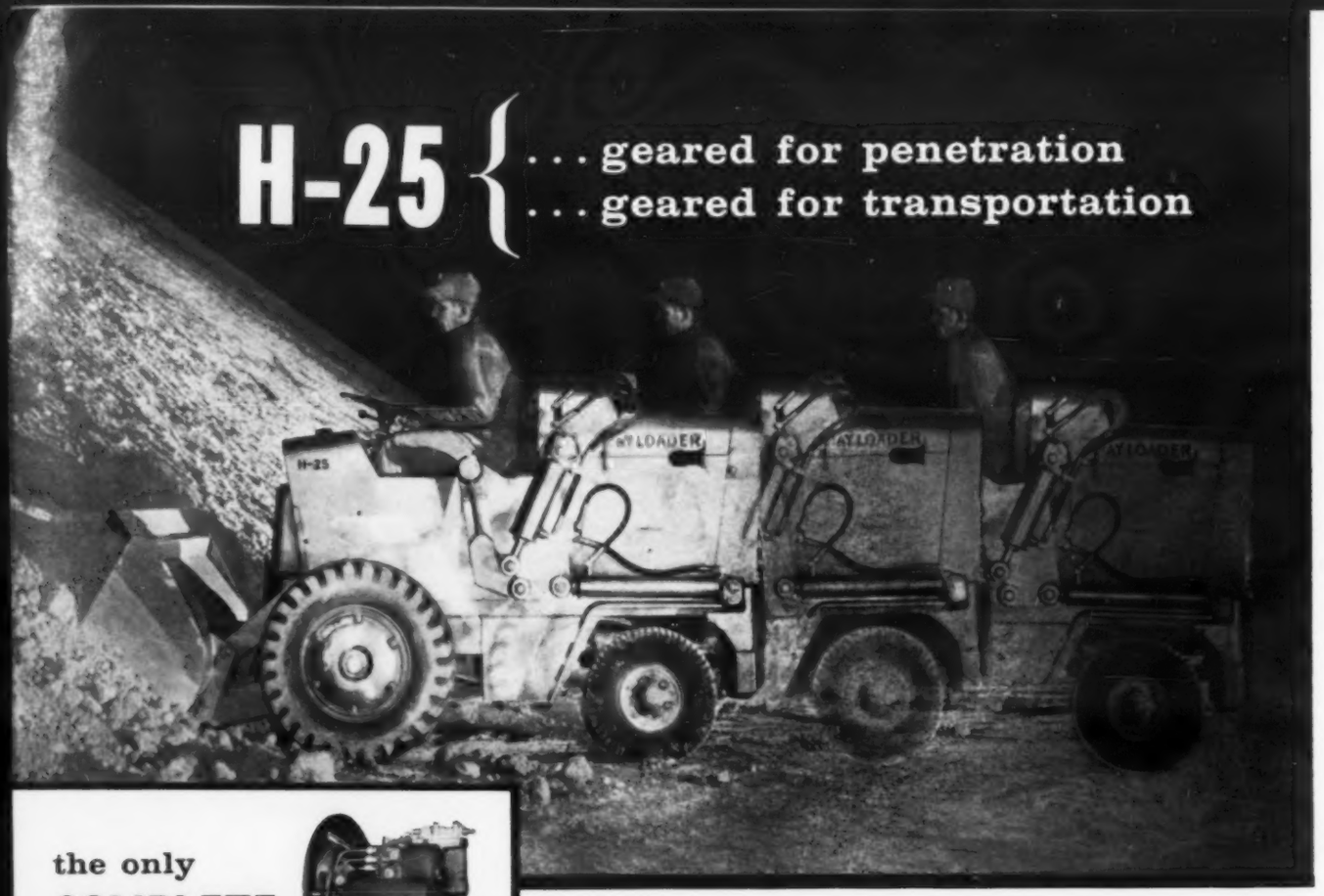
There will be on exhibit castings of every material—gray iron, ductile iron, malleable iron, steel, aluminum, magnesium, brass, bronze, titanium and zinc; and made by every process—green sand, core sand, shell mold, CO_2 mold, permanent mold, die-cast, investment, plaster, centrifugal and vacuum cast.

Concurrent with the Show will be the 63d Castings Congress with a technical program of more than 100 papers presented in 41 sessions, five shop courses and seven round table luncheons. A substantial number of papers will be of mutual interest to both casting users and producers. Each of the seven AFS Technical Divisions will contribute to the preparation of a large informative casting exhibit. Each Division will also sponsor a session on casting design, applications, engineering, or purchasing.



Potential exhibitors will receive applications in September giving all the necessary details for entering the Show. The success of the 1st Show in Cincinnati in 1957 has encouraged many more foundries to plan to use this new medium to promote the use of castings, to influence the thinking of designers and to direct the attention of casting buyers to their metalcasting "know-how."

H-25 { . . . geared for penetration . . . geared for transportation



the only
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power-shift
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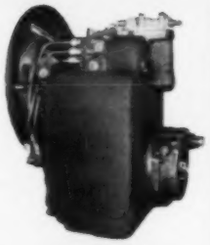

. . . having two speed ranges forward and two in reverse — the low range for digging power and close maneuvering—the high range for fast, economical travel in either direction.

All shifting, forward or reverse, is an instant finger-tip action with no need to stop between range shifts. The torque-converter is carefully matched with the transmission and is the more costly and more efficient two-phase type that automatically becomes a thrifty fluid drive when torque multiplication is not needed. Transmission and converter also keep comfortably cool because their oil is radiator-cooled.

This new **PAYLOADER**® has more hustle than you've ever seen in a tractor-shovel. It's got everything to turn out big production all day long with the least operator effort and is the only machine in its class with *complete* power-shift transmission and power-steer. The carry capacity of 2,500 lbs. is 25% greater than has ever before been available in a tractor-shovel of its size and maneuverability, yet it easily goes in and out of boxcars with narrow 6-foot doors.

Another valuable and exclusive feature is the power-transfer differential that makes traction more effective and reliable at all times because the wheel with the better grip automatically gets the most power.

The H-25 is *full* of other plus features that mean more production, less maintenance and longer life: closed hydraulic system, wet-sleeve overhead valve engine, triple air cleaners, full-shift fuel capacity, 4,500 lbs. of bucket breakout force and 40° bucket tip-back, to mention only a few.

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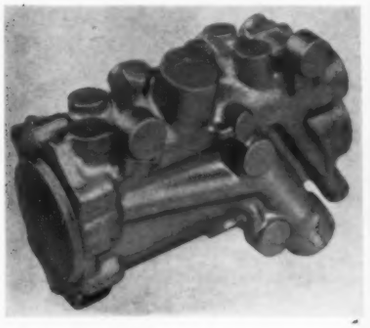
Problem Casting . .

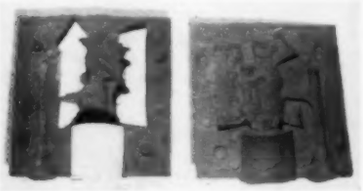
■ The "problem casting" dilemma can often be solved by using the best features of more than one casting process. This approach was recently applied successfully to casting the main body of an after-burner fuel ignitor valve component by Foundry Products Div., Cooper Alloy Corp., Hillside, N. J.

Early efforts to produce this casting, both by Cooper Alloy and other foundries attempting it, had met with



little success. Part of the problem lay in need for a tough, heat-resistant tool steel casting that could withstand elevated temperatures. Also the casting had to be flaw-free under x-ray, zyglo and magnaflux inspection. Cooper Alloy 15A, a stainless steel, proved a good choice.

Because of its complex shape, the part had to be cast to close tolerances. Early attempts to machine



such off-center castings had always proven expensive. Chucking the irregular piece is in itself a difficult and time-consuming job.

Core molds were originally specified, but odd-shaped pattern required could not be made with straight-line parting. Rejection rate was high—shifting or crushing of cores within mold was one contributing factor; inexact core fitting another.

Laboratory experiments proved the method of making castings in shell molds using shell cores to be sound. The firm, smooth and true surface

Circle No. 244, Page 7-8

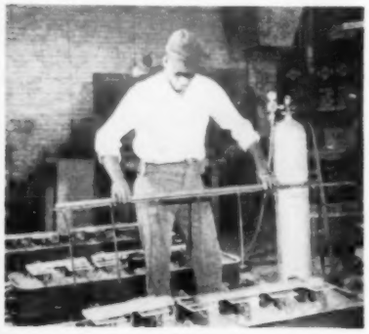
Combines Processes

of both shells and cores assured close core alignment and a smooth casting surface requiring less finishing.

A shell mold pattern was laid out so that cores were eliminated in the cope section, simplifying setting of cores in the assembly. Metal run out was the next problem. Green sand backing to prevent run out resulted in dimensionally unstable castings because of mold deflection.

The problem was solved by ramming sodium silicate bonded sand into a flask around shell molds and gassing with CO_2. The rigid backing completely prevented mold deflection. The operation required only a CO_2 gas cylinder with a specially designed fork-shaped gassing unit attached to it.

The bulky casting required a large head, resulting in low yield per heat. Riser efficiency was greatly improved



by surrounding it with an exothermic insert—a tube-like device called a "hot-sleeve." This insert permitted smaller amount of head or feed metal to remain molten longer enabling Cooper Alloy engineers to increase yield per 1550-lb heat from 42 castings to 70.

By combining the use of shell molds and cores, the CO_2 process and the use of a "hot sleeve," Cooper Alloy reduced the reject rate for this casting 75-80 per cent.

The smooth surface produced by shell molds and cores resulted in less finning. Cleaning room time was cut from 45 to 15 min per piece. "Hot sleeves" increased the casting yield core and "hot sleeve" assemblies can be made in advance and stock-piled, rush-order deliveries were met without difficulty. Over 6000 castings have been made from one set of equipment.

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CONVENTION SYMBOL OF A SEARCHING MIND

HATS OFF to the vast crowd who searched the 62nd Castings Congress for ways to produce better castings! We are hopeful that those who visited the ADM-FEDERAL display took away more than the jaunty Archer cap you see in evidence on this page. The cap was only a festive way of expressing the more serious thought, "aiming toward better castings."

The array of new products seen in the ADM-FEDERAL booth is the means to that end. As an example, hundreds of visitors took a field trip to the ADM plant to see a preview demonstration of ADMIREZ GS-300, a revolutionary gas-setting binder promising unheard-of speed, accuracy, and economy. LIN-O-SET A-200, an entirely new air-setting binder, was successfully kicked off at the convention. Three new refractory washes for use on shell, CO_2, air-set, or oil bonded cores were introduced: ZIRCON WASH #973, CERAMIC WASH #974, and SIL-PLAST #995.

We trust that the intense interest shown in these products is evidence to *all* searching minds that the Archer offers practical answers to faster core and mold production at lower cost. Check your interests on this coupon and mail it to Archer-Daniels-Midland.

And remember, all Archer trademarked supplies are *sold with service!*

Archer Daniels Midland company

FEDERAL FOUNDRY SUPPLY DIVISION
2191 West 110th Street • Cleveland 2, Ohio

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- ☐ ADMIREZ GS-300 Gas-Setting Foundry Resin
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- ☐ CROWN HILL Sea Coal
- ☐ LIN-O-SET A-200 New Air-Setting Binder
- ☐ LINOIL Core Oils
- ☐ ADM-FEDERAL Facing Compounds
- ☐ ADM-FEDERAL Core & Mold Washes, Zircon No. 973, Ceramic No. 974, and Sil-Plast No. 995
- ☐ GREEN BOND Bentonites
- ☐ FREFLO Parting Compounds
- ☐ ADM-FEDERAL Sand Stabilizers
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Circle No. 246, Page 7-8

Build an idea file for plant improvements. The post-free cards on page 7-8 will bring more information on these new . . .

products and processes

INDUCTION MELTING . . . through simple unit for converting frequency. Unit is a static-frequency multiplier, taking, for example, 3-phase power at 60 cycles directly from ordinary supply line and delivering single-phase power to furnace through conventional lines. Output may be varied continuously, and under load, between

zero and maximum. Company claims furnace power supply cost is two-thirds to three-quarters that of conventional motor-generator type equipment. Lower maintenance cost as there are no moving parts. Operation said to be almost automatic and easy for inexperienced operator use. *Ajax Electrothermic Corp.*

For Manufacturer's Information
Circle No. 281, Page 7-8

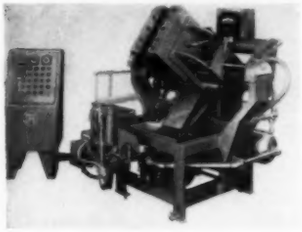
RESONANCE BONDING . . . of mold and core sands hardens sand without use of heat, ovens or gassing equipment. Manufacturer claims setting and hardening time can be adjusted to suit individual needs by means of "delayed chemical action," and that materials and principles of new process reduce hardening time of shell molds while increasing their size; water toleration also is increased. Process will increase size and reduce cost of investment castings, and will result in use of finer sands and reduced permeability for all molding methods. *Coldhard-HiUtek Div., United States Trading and Service Corp.*

For Manufacturer's Information
Circle No. 282, Page 7-8

MATERIALS HANDLING LEASING . . . plan gives opportunity to modernize materials handling, shipping and storage without large investment. Company offers steel wire containers and pallets for rental of three to five years with option to buy at the end of the rental period. Rents paid on monthly basis. *Tri-State Engineering Co.*

For Manufacturer's Information
Circle No. 283, Page 7-8

HOLLOW-CORE MACHINE . . . single station, fully automatic or manually operated. Said to be ideal for fast, economical, production of wide variety of hollow cores and shell molds, especially when mixed types and sizes are blown simultaneously. According to manufacturer, one attendant can operate a line of fully-automatic machines or two manually-



operated units. Unit is designed to permit easy unloading without reaching or stretching. Accommodates core boxes from 3-9 in. thick, 1-16. deep and 5-21 in. high. Up to 30 lb or solid core can be blown. *Spo, Inc.*

For Manufacturer's Information
Circle No. 284, Page 7-8

ALUMINUM ALLOY . . . claimed to provide castings high strength and ductility with resistance to industrial and marine atmospheres. Developed to fill need for alloy not requiring

You Need A Rest!

Yes — you've earned a well-deserved vacation. Time off to relax — and play — and

THINK.

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Get Away From It All!

A Sizzling pan
full of fish — a tall, cool drink or
a pot full of good coffee — a cool place
in which to stretch out — and just relax.
Man, you'll have it made!
But you'll "keep cool" all year long if
you turn to **MODERN CASTINGS** for the
latest in metalcasting technology.
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Vacation time is here!
Whether it's tennis, golf or
birdwatching — whatever
you do — you'll have more fun doing it
if you forget your problems.
Bolster up your problem-solving
Idea File!
Circle these letters and numbers for the latest
information about
technology and equipment; and . . .

(have a **good time!**)

special quenching techniques to impart high tensile strength. Recommended for aircraft structural castings; construction or mechanical equipment subject to impact loads; and equipment for dairy, food and chemical industries. *Aluminum Co. of America.*

For Manufacturer's Information Circle No. 285, Page 7-8

EPOXY MOLDING . . . compound reportedly offers for the first time high strength coupled with exceptional conformability. Users report average flexural strength of 100,000 psi, average tensile strength of 40,00 psi and average compressive strength of 38,000 psi at normal temperatures. Supplied in dry form and adaptable to either compression or transfer molding processes. Glass content, 66 per cent; resin content, 34 per cent. Manufacturer states that once molded, the material offers the good dimensional stability characteristic of epoxy resins. *Minnesota Mining and Mfg. Co.*

For Manufacturer's Information Circle No. 286, Page 7-8

SALT TABLETS . . . with vitamins B_1, B_2 and C added, when used in amounts recommended are said to replace necessary salt in the body and to give minimum adult requirements of the three vitamins. Manufacturer reports employees using this product will feel better, work better and will have more resistance to heat fatigue. *United States Safety Service Co.*

For Manufacturer's Information Circle No. 287, Page 7-8

HIGH TEMPERATURE ALLOY . . . designed for castings which are to be used at temperatures up to 2000 F. Manufacturer states alloy is superior in thermal fatigue, resistance to creep, and surface stability either in oxidizing or low oxygen pressure atmospheres. Recommended for furnace trays, shafts, mill guides, radiant tubes and other heat resistant castings. *Blaw-Knox Co.*

For Manufacturer's Information Circle No. 288, Page 7-8

STEEL GLOVES . . . Four ply stainless steel mesh is sewn to cotton flannel base. Manufacturer reports gloves provide easy flexing with maximum protection against sharp or abrasive objects. May be worn as produced or can be used as liner under any other work glove. Available in gauntlet style with full coverage or breathing backs with palm and finger coverage only. *Surety Rubber Co.*

For Manufacturer's Information Circle No. 289, Page 7-8

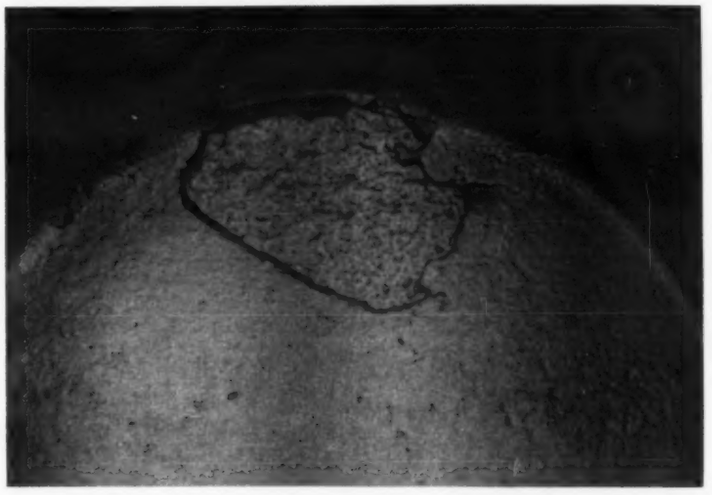
METAL FILLED EPOXY . . . resins designed to make strong castings with properties similar to metal castings, make molds for short-run use and for

VOLCLAY BENTONITE

NEWSLETTER No. 9 REVISED

REPORTING NEWS AND DEVELOPMENTS IN THE FOUNDRY USE OF BENTONITE

SCABBING



The chief source of expansion scabs, is high sand expansion combined with high hot strength.

The expansion scab is the breaking away of a portion or slab of the molding sand when hot metal enters the mold. The broken away portion of the sand adheres to the metal or is absorbed into it.

Uneven ramming and a high mold hardness can lead foundries into this difficulty if no protection is added in the sand mixture.

Cellflo, a grain cellulose material, and **Five Star** Wood Flour, a cellulose hard wood fibre, insure against scabs when added to a sand mixture.

Newsletter No. 38 Is Also Available On This Subject.

WRITE FOR FURTHER DATA AND SAMPLES THROUGH YOUR FAVORITE DEALER.

AMERICAN COLLOID COMPANY

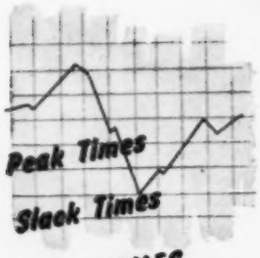
SKOKIE, ILLINOIS • PRODUCERS OF VOLCLAY AND PANTHER CREEK BENTONITE

Circle No. 247, Page 7-8

ABC Coke Plant, Tarrant, Ala.

ABC

— a strictly independent Merchant Coke Producer



ALL TIMES

You can depend on your source of supply for

ABC QUALITY COKE!

Since ABC was formed in 1920, it has maintained its position as a strictly independent merchant coke producer, with no blast furnace or other affiliations having first call on its production.

That is one reason why customers of ABC have always found it a dependable source of supply under all conditions of the market.

ABC's capacity of some 875,000 tons of coke per year from 203 modern Koppers and Becker type ovens enables it to fill orders promptly without ever sacrificing the high quality standards that ABC has always upheld.

ABC maintains at all times a minimum of 60 days' reserve stocks of coal at its large ovens to insure uninterrupted service.

ABC Foundry Coke is produced in two distinct types — standard and malleable — in sizes to meet the most exacting requirements of any foundry operation. Your inquiries are invited.

ALABAMA BY-PRODUCTS CORPORATION

General Sales Office: First National Building, Birmingham, Alabama

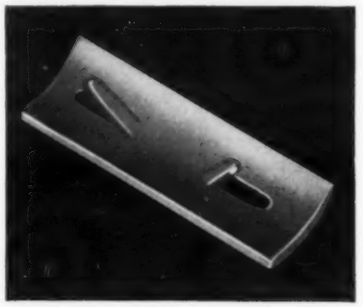
Sales Agents: GREAT LAKES FOUNDRY SAND COMPANY, Detroit; ST. LOUIS COKE & FOUNDRY SUPPLY CO., St. Louis; THE RANSOM AND ODE COMPANY, Cincinnati; KERCHNER, MARSHALL AND COMPANY, Pittsburgh; RAISORE, BUTNER & COMPANY, LTD., San Francisco; ATWILL COKE AND COAL COMPANY, Chicago.

Circle No. 248, Page 7-8

filling voids and plugging holes in metal structures, wood, plastics. Two-component material cures at room temperature and is said to have excellent machining properties. Sets in four hr at 70 F and in one hr at 120 F. *American Latex Products Corp.*

For Manufacturer's Information Circle No. 290, Page 7-8

RADIUS CHILLS . . . with angled prongs designed to hold chill tightly in rammed-up core. Prong holes can be used in conjunction with core box



vents. Said to eliminate use of nails, resulting in labor and material savings. *W. L. Jenkins Co.*

For Manufacturer's Information Circle No. 291, Page 7-8

SOUND PROTECTED . . . welding helmet features ear domes said to effectively protect against high and low frequency noises. Designed to protect welders who work where

there is exceptional noise. Ear domes swivel to fit any shape head. Unit claimed to be effective even when worn over personal or safety glasses. Replaceable ear puffs. Entire unit fire and rust-proof. *American Optical Co.*

For Manufacturer's Information Circle No. 293, Page 7-8

REPEATING AIR HAMMER . . . employs versatility in foundry applications such as trimming gates from castings, parts assembly, chipping, riveting, impression marking and others. Hammer repeats at from 1000-2500 times per min, operated by foot pedal.

At 20 lb pressure, hammer has gentle motion, useful for delicate work; at 100 lb pressure, it rivets 5/8-in. diameter in mild steel. *Heidrich-Nourse Co.*

For Manufacturer's Information Circle No. 294, Page 7-8

BOTTOM DISCHARGE . . . crane ladles for pouring large quantities of slag-free metal. Features geared discharge mechanism engineered to minimize ladle space requirements and promote safety. Provides 18 lever positions for adjusting operating lever to proper pouring height. Available in four models, 10,000-40,000-lb capacities. *Industrial Equipment Co.*

For Manufacturer's Information Circle No. 295, Page 7-8

PORTABLE MELTING FURNACE . . . claimed to eliminate coasting-over as lining stores no heat. Uses 3-5 gal of oil per hour of melting; holds metal at correct pouring temperature; and needs no outside flue. Capacity 150-300 lb. *Industrial Scale & Equipment Co.*

For Manufacturer's Information Circle No. 296, Page 7-8

SHELL MOLD . . . release agent eliminates sticking, break-in, build-up and cleaning of shell mold patterns and core boxes. Applied by spray or brush, coating tested to withstand temperatures over 1000 F. Smokeless, non-toxic and inert, material said to be an effective high temperature lubricant. *Chem-Cote Co.*

For Manufacturer's Information Circle No. 297, Page 7-8

BRASS AND BRONZE . . . ingots produced by process featuring bottom pouring in a controlled atmosphere of dry nitrogen gas. Manufacturer claims procedure controls oxidation and hydrogen pick-up from atmospheric humidity. *I. Schumann and Co.*

For Manufacturer's Information Circle No. 298, Page 7-8

FERROUS CLEANING . . . material, removal of light films of oil, shop dirt, paint and rust deposits from ferrous metal parts. Mixture contains strong alkalies, corrosion solubilizing compound and a wetting agent. Product releases no corrosive fumes. *Magnus Chemical Co.*

For Manufacturer's Information Circle No. 299, Page 7-8

REFRACTORY LINING ANCHOR . . . system designed to increase life of plastic and castable refractories used in soaking pit covers and heating furnace roofs. Flexible system supports each refractory tile in cradle, giving ball and socket action tending to reduce tile breakage occurring with other types of suspension, company officials state. Features said to include: reduced cost per sq ft of suspension;

NOW FLEXIBLO HAS A PARTNER

IT'S THE

FLEXIGAS

In 7 Sizes For Low-Cost CO_2 Curing of Molds and Cores

Each size Flexigas completely adjustable to any mold or core within its range.

Fully automatic operation—push-button control.

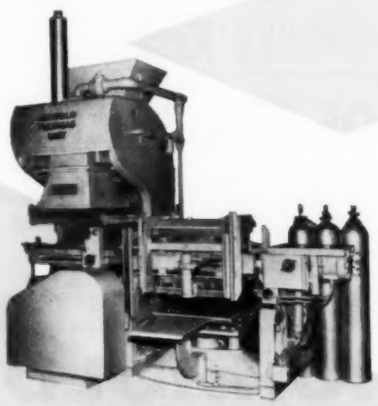
Each Flexigas is compact and rugged—built to operate with minimum maintenance.

Use *individually* or in complete Flexiblo-Flexigas *units*.

Economical operation—uses just the right amount of CO_2—no more, no less. High quality and uniformity are assured with minimum cost operation.

CB5 FLEXIGAS

A complete range of Flexigas units to handle any size mold or core to 400 lbs.



SEVEN FLEXIBLO-FLEXIGAS UNITS—CAPACITIES TO 400 LBS.

CB5	FLEXIBLO-FLEXIGAS	4½ lbs.
CB10	FLEXIBLO-FLEXIGAS	20 lbs.
CB12	FLEXIBLO-FLEXIGAS	30 lbs.
CB15	FLEXIBLO-FLEXIGAS	70 lbs.
CB18	FLEXIBLO-FLEXIGAS	125 lbs.
CB20	FLEXIBLO-FLEXIGAS	125 lbs.
CB30	FLEXIBLO-FLEXIGAS	400 lbs.

Note: Flexiblo-Flexigas units, except the CB5, are available as blow-squeeze-gas units.

HIT OF THE CLEVELAND FOUNDRY SHOW

BEARDSLEY & PIPER

Division Pettibone Mulliken Corp., 2424 N. Cicero Avenue, Chicago 39, Illinois

Circle No. 249, Page 7-8

EDSEL CRANKSHAFT—

Economic Production With RCI FOUNDREZ Resins In

THE SHELL MOLD STORY OF THE YEAR

You see here one of the largest shell mold castings now in mass production. It's the Edsel crankshaft. And an RCI phenol formaldehyde FOUNDREZ resin is used extensively to produce the shell molds.

Edsel production engineers have found many advantages in use of the shell mold process for this important casting. For example, the shell molds reproduce patterns more exactly. They are portable and use less sand. Castings have closer dimensional tolerance, require less machining. In general, foundry efficiency, flexibility and production rate are increased.

There are also good reasons why Edsel uses RCI FOUNDREZ resins. For one thing, continuity and quality control in resin manufacture are assured because RCI is a basic producer of both phenol and formaldehyde. In addition, 35 years of wide experience in synthetic resin manufacture is concentrated in RCI's Detroit plant, where these FOUNDREZ materials are produced.

If you have a foundry job where shell molding may offer advantages, write the RCI Foundry Division for full information on FOUNDREZ resins.

REICHHOLD

FOUNDRY PRODUCTS

FOUNDREZ—Synthetic Resin Binders
coRCIment—Core Oils
COROVIT—Self-curing Binders

Creative Chemistry . . . Your Partner in Progress

RCI

REICHHOLD CHEMICALS, INC.,
RCI BUILDING, WHITE PLAINS, N. Y.

Circle No. 250, Page 7-8

cradle is stronger than a casting; on reline jobs the refractory anchor is the only replacement needed; anchors move in any direction; tile shaped to withstand rugged handling and no grooves to weaken the tile. *Refractories Div., H. K. Porter Co.*

For Manufacturer's Information Circle No. 300, Page 7-8

CORE BOX TRACK . . . designed to transport core boxes, 9x9 in., weighing up to 10,000 lb on double-wheeled dollies riding on twin rails. Track is said to be easily adapted for carrying extra large or very heavy loads by using fabricated metal pallets or carriers. *Nomad Equipment Div., Westover Corp.*

For Manufacturer's Information Circle No. 301, Page 7-8

PRECISION GAUGE . . . for measurement of thickness of castings, pipe walls, grooves, lumber, etc. Made in Germany, caliper gauge gives rapid, accurate measurements requiring the

use of only one hand; the other free to hold test specimen. Four different shapes of contact points available for various measurements. Gauges made to meet special requirements. *Bemax Import-Export Co.*

For Manufacturer's Information Circle No. 302, Page 7-8

HEAT - RESISTANT FACE VISOR . . . for research personnel and others who must observe molten metal or extremely hot objects; said to permit facing radiant heat above 2000 F without discomfort. Shatterproof visor effectively reflects 95 per cent of the infra-red rays. Manufacturer states that visibility is high and temperature between face and visor remains at approximately 80 F. *New York Air Brake Co.*

For Manufacturer's Information Circle No. 303, Page 7-8

SAND SLINGER CUPS . . . stated by officials to combine optimum high wear resistance with toughness, outwearing mild steel cups by three-to-one ratio in all sand conditions. *Latrobe Steel Co.*

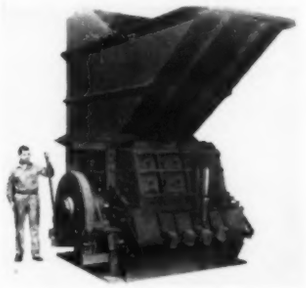
Circle No. 304, Page 7-8 For Manufacturer's Information

BENTONITE TESTING . . . sets for Liquid Limit testing of western bentonite used as binder in core and mold sand or in preparation of core

and mold washes in foundries. Test involves a few pieces of basic laboratory equipment. Set includes high-speed mixer, testing cup, and scribing tool used to groove the sample. *Soiltest, Inc.*

For Manufacturer's Information
Circle No. 305, Page 7-8

METAL CRUSHER . . . for heavy duty reduction of scrap, castings, etc.,



at a rate of 20-40 tons per hr. Can result in substantial savings in storage. *American Pulverizer Co.*

For Manufacturer's Information
Circle No. 306, Page 7-8

CLEANING ABRASIVE . . . is said to provide improved cleaning quality, faster cleaning speeds and lower costs because of the narrow hardness range, extreme uniformity, density and toughness. Abrasive shotted by new vacuum cast process which officials state provides greater density and eliminates discontinuities. All S.A.E. sizes available. *Pangborn Corp.*

For Manufacturer's Information
Circle No. 307, Page 7-8

RADIANT ROOF PANELS . . . ready for installation in aluminum melting furnaces are reported to facilitate economic rebuilding of furnaces and to offer increased heating efficiency for die casting, sand casting and permanent mold casting of aluminum. Panels consist of radiant cup type burners mounted in one-piece refractory tile casting, permit great reduction in furnace wall space, cutting heat loss. *J. A. Kozma Co.*

For Manufacturer's Information
Circle No. 308, Page 7-8

HIGH-SPEED X-RAY FILM . . . for industrial use has approximately 50 per cent more speed than company's fastest industrial x-ray film presently available. Officials state the film will prove valuable in cutting exposure time in radiographic inspection of thick sections of large castings without sacrificing radiographic sensitivity. *Eastman Kodak Co.*

For Manufacturer's Information
Circle No. 309, Page 7-8

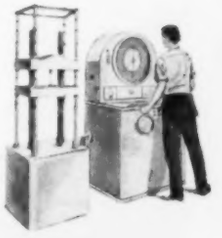
Circle No. 251, Page 7-8

"I always get good ductility using calcium alloys"

Steel foundries employing aluminum deoxidation obtain improved properties by making a supplementary addition of calcium-silicon or calcium-manganese-silicon to the ladle. These calcium alloys help obtain consistently good ductility in the tensile test. Many foundries also report improved fluidity with the calcium additions. Generally 3 to 5 lbs. of alloy per ton insure effective treatment.

ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 East 42nd St., New York 17, N. Y.

Contact your ELECTROMET representative for further information on getting improved ductility with calcium alloys.



Electromet
FERRO-ALLOYS AND METALS

UNION CARBIDE

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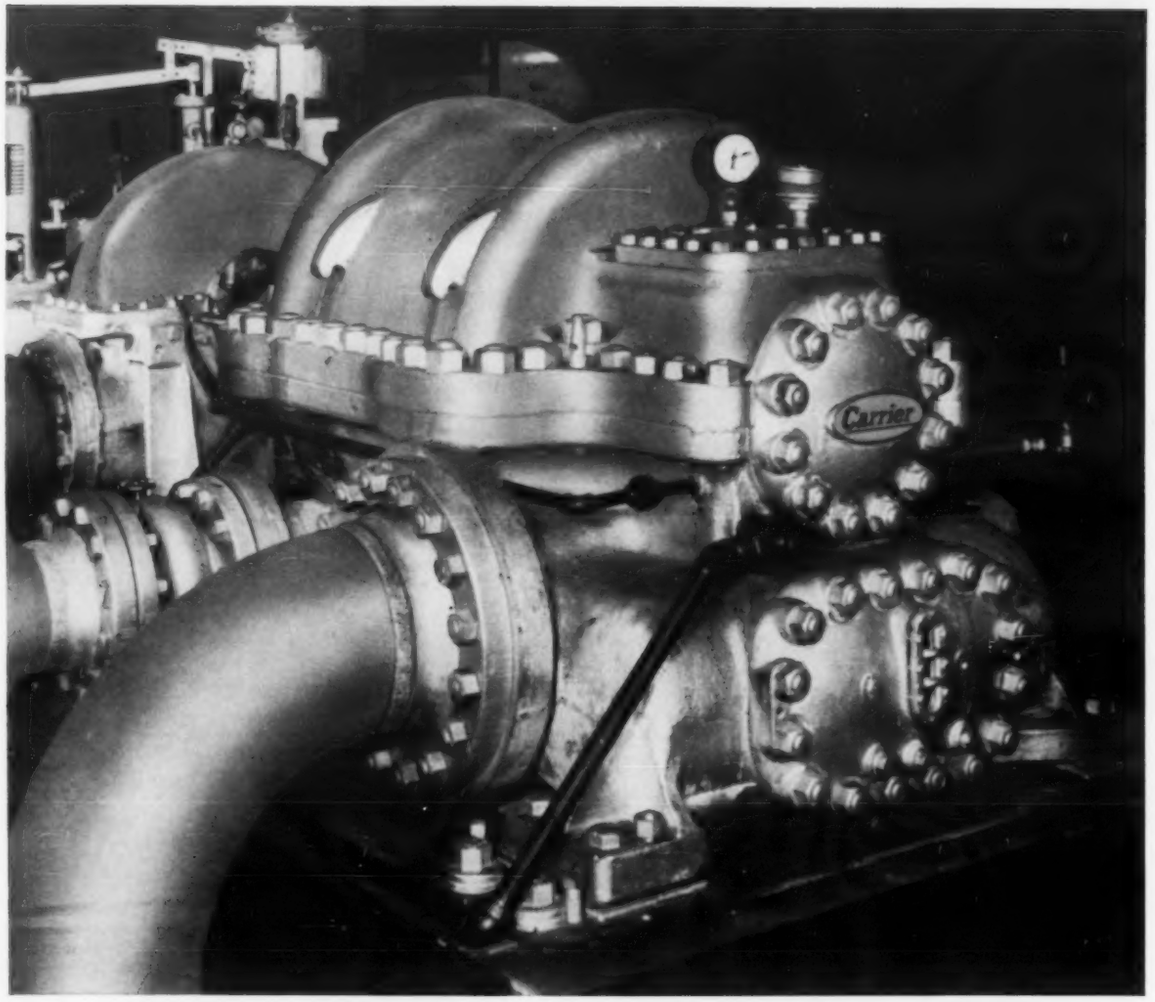


4½% Nickel plus good casting makes these casings strong and tough at–185°F

Here's how the foundry solved a low temperature problem:

This Carrier #350 Compressor is designed for producing ethylene by low temperature (–185°F) high pressure (600 psi) fractionation.

Under these conditions ordinary cast steel is brittle and could easily fracture. Could the foundry turn out castings which would have high strength and toughness at the low temperatures involved?

They could . . . this way:

They made these three-ton compressor housing castings from 4½% nickel alloy steel; normalized and water quenched them, and finally tempered them. Under this treatment the castings easily exceed these minimum mechanical properties:

Ultimate tensile strength	70,000 psi
Yield strength	40,000 psi
Elongation in 2"	22%
Reduction of area	30%
Charpy keyhole impact (@ –185°F)	15 ft. lb.

Nickel does wonders for cast irons and steels destined for severe service . . . aids development of desired metal structure.

Recommend Nickel Alloys Freely

Nickel is a plentiful and versatile material and you can count on Inco Nickel's Development and Research Division for information to help you in selecting specific materials to use in particular applications.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N.Y.

INCO NICKEL

NICKEL ALLOYS PERFORM BETTER LONGER

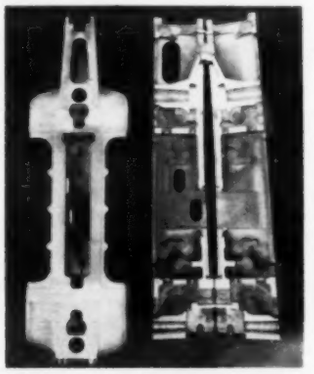
product reports

Save weight

. . . up to 25-40 per cent with use of new aluminum alloy. Parts formerly producible to required strength only by forging are now being produced by both sand and permanent mold methods.

Manufactured by Navan Products, Inc., Santa Monica, Calif, Tens-50 alloy is currently being employed to solve the problem of casting by permanent mold the high-pressure hydraulic valve shown here. Triple A

Metalcraft Corp., Los Angeles, discovered that a maximum burst pressure of 5,600 psi could be achieved by conventional alloys. Specifications called for 7,500 psi. When Tens-50 was poured in the same mold, a test



Three-part mold for large pylons uses seven metal cores and six sand cores.

of 10,000 psi without bursting was achieved.

In this aluminum alloy, beryllium and sodium are used to neutralize the embrittling effect of iron and silicon, reportedly offering consistent results under average foundry conditions.

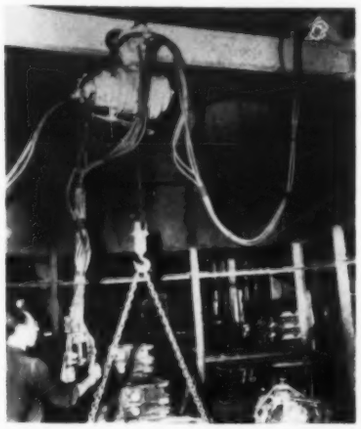
For Manufacturer's Information Circle No. 316, Page 7-8

Saves $4000 annually

. . . in mold-moving operation which required two men to remove the mold from the conveyor, place it on shakeout and lift the flask to the return conveyor. This foundry was equipped with an Ingersoll-Rand 2000-lb ca-

pacity air hoist with standard trolley mounted on a jib crane.

To eliminate pushing and tugging to get the mold into position, the air



hoist was equipped with Pendent Controls and an Air Motor Trolley to move it along the jib. The moving end of the jib crane was fitted with

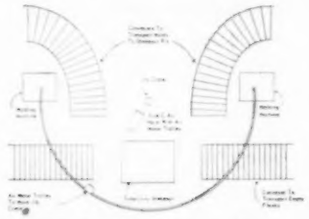


Diagram of mold-moving operation.

similar controls. The three sets of Pendent Controls were grouped together, along with push buttons to operate the shakeout grate.

As a result, one man now operates the mechanized unit, reportedly with greater speed and less fatigue, freeing the other man to operate an additional installation.

For Manufacturer's Information Circle No. 317, Page 7-8

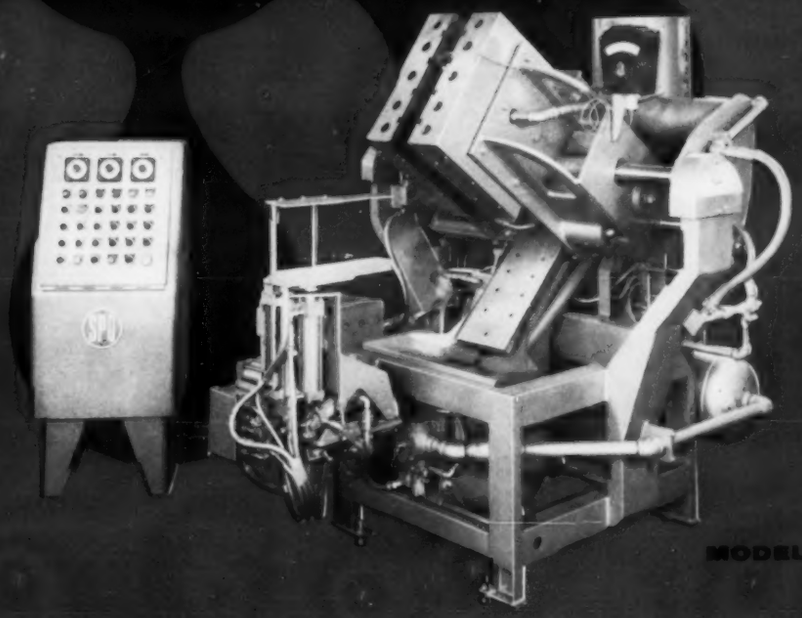
Plastic foam resin

. . . material is one that many imaginative patternmakers and foundrymen should find new uses for in their shops. Using fiberglass molds, Chance Vought Aircraft, Inc., Dallas, Texas, is turning out small wind tunnel models of Devcon "B" plastic foam, manufactured by Devcon Corp., Danvers, Mass.

Instead of making models by hand out of balsa wood or constructing them of fiberglass with balsa wood bulkheads, foam-plastic method was adopted because it produced a light, strong

Circle No. 252, Page 7-8

SPO's ANGLE-BLO holo-core MACHINE
with fully automatic unloader



MODEL SC-30

SPO ANGLE-BLO DESIGN

With core box at 45° angle, uncured sand drops out of upper horizontal arms of core as core box rocks away from blow plate. As box rocks to unloading position, remaining uncured sand drains, leaves cured core with uniform walls.

SPO's new holo-core machine blows, cures, strips, unloads hollow cores or shell molds, recharges sand magazines . . . automatically and without operator attention!

Model SC-30 will mass produce a wide variety of hollow cores and shell molds quickly, economically . . . handles core boxes up to 16 x 21 x 9 inches . . . blows 30 lbs. of solid core . . . permits selection of cycle time and temperature best suited to individual pieces. Before you buy any core blowing equipment, get all the facts on SPO's ANGLE-BLO design.

Write for Bulletin SC-30

SPO

SPO INCORPORATED

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- CHROM-ADD BRIQUETS offer the foundry an economical and convenient method of adding chromium to the ladle.
- Additions of up to 3% chromium can be made with uniformly high recovery and without reducing metal temperature.
- Used either alone, or in combination with other alloys, CHROM-ADD BRIQUETS assure complete solution and uniform alloy distribution in the ladle.
- Ladle additions can be made by count. Each CHROM-ADD BRIQUET weighs approximately 4.3 lbs. and contains exactly 2 lbs. of chromium. CHROM-ADD BRIQUETS are packed 12 to a carton, each briquet in its own container.

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model at lower cost.

Mold is lined with a layer of fiberglass before the liquid resin and catalyst are poured into it. A chemical

reaction expanded the small quantity of waxy liquid until it fills the mold tightly welding itself to the fiberglass which forms a smooth outer skin.

For Manufacturer's Information Circle No. 318, Page 7-8

Saves sampling time

. . . of heats at Wolverine Tube, Div. Calumet & Hecla, Inc., Decatur, Ala., through use of a shop-made revolving table on a Rockwell-Delta drill press, a product of Rockwell Mfg. Co., Pittsburgh, Pa.

The revolving table holds a vice in which a metal sample, removed from furnace, is clamped. The lab technician drills the sample and dumps the shavings and sample into

a pan by rotating the table 180 degrees, rapidly clearing the table and vice. The table also turns on the column so that the piece may be quickly positioned under the spindle.

This setup reportedly cuts at least one minute off waiting time, an important saving when sampling 134 heats per day.

For Manufacturer's Information Circle No. 319, Page 7-8

Circle No. 253, Page 7-8

the editor's field report

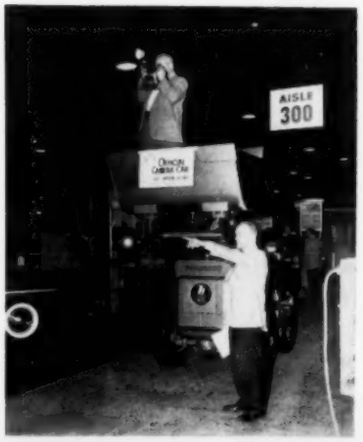
by Jack Salmon

■ In Europe molten baths of Al-10% Si alloy are being substituted for lead baths and salt baths as heat treating media for steel. The aluminum baths have been used successfully for tempering steel castings at 1000-1300 F and as a heating medium prior to quenching. The advantages are readily apparent. Aluminum is much lighter than lead and consequently considerably cheaper for the same volume bath. Also a sturdier structure is needed to support heavy lead baths. No toxic fumes are given off from aluminum. Compare this with fuming hot salts or lethal lead vapors. Expensive alloys are needed to resist the corrosive attack of molten salt baths. With malleable iron producers eyeing the advantages of salt bath annealing they might also check into the possibilities of using aluminum baths to speed their heat treatments.

■ One of the latest tricks of high speed mold production combines mold blowing with CO_2 gassing. When using stack molding techniques this means that each mold forms a cope and drag. A machine of this type attracted a lot of attention at the AFS Show. It was capable of producing 240 cope-drag stack molds per hour. Next month Modern Castings will carry a story describing how American Foundry & Machine Co. built their own CO_2 stack molding equipment and what they are doing with it.

■ While on the subject of molding and the AFS show several other machines deserve mention. One manufacturer makes green sand cope and drag on opposite sides of matchplate simultaneously. The mold halves are drawn away from plate; plate is swung aside; mold halves are closed; ram-up flasks are slipped off and flaskless mold is ready for pouring. Another molding machine has cope and drag matchplate mounted face up alongside of each other on jolt table permitting both mold halves to be made simultaneously. Still another machine jolts the sand around pattern and then presses the pattern into the sand about one inch instead of using the conventional squeeze from the top surface of mold.

■ In case you might have wondered how Modern Castings managed to present a bird's-eye-view of the AFS Show in the June issue, here's a picture that tells the tale. This mobile "sky-hook" was graciously provided by the Frank G. Hough Co., Libertyville, Ill., along with a skilled operator. With this unique means of locomotion we were able to make a photographic tour of the Show in record time. The advantages are apparent to anyone who has attempted to take such photos from floor level where people have the uncanny ability to walk in front of the camera every time the shutter clicks!



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Circle No. 254, Page 7-8

SAVING CAPITAL

Leased production equipment can free a foundry's working capital and help earn profits

WILLIAM R. HEINS / *President*
United States Leasing Corp.
San Francisco

About $180,000,000 worth of leased equipment is currently in use in industry generally. About 1-1/2 per cent of this total is estimated to be in use by the foundry industry—about $2,700,000 worth of leased equipment. Five years ago the total amount of leased equipment in the foundry industry was about $400,000. In 1948 it was practically nothing. It is estimated that the total will double in the next four years (if the economic cycle doesn't wobble too much). This would mean about $5,400,000 of leased equipment in the foundry industry by 1962.

Your foundry can lease:

- Fork lift trucks
- Molding machines
- Conveyors
- Front end loaders
- Cupolas
- Melting furnaces
- Heat treating furnaces
- Core ovens
- Core blowers
- Cranes
- Scales
- Sand mixers
- Ladles
- Cleaning equipment

in fact, almost anything!

"It's getting so I can rent a new suit, hat and coat more conveniently than I can buy," a company president remarked recently. To some foundries, this little pleasantry may not seem especially strange. Many of them rent all their new lathes, presses, cranes—in fact the full gamut of machinery and equipment. To other foundries this leasing trend may be something new.

The major virtue of leasing is that it frees working capital for company expansion of sales, for taking of all trade discounts, for building balanced inventories for seasonal needs, for making more credit available to customers, for expanding research and development work—in short, for all the customary uses of working capital.

Why lease? Leasing is no cure-all, no infallible solution to all the financing problems of business. Leasing has certain virtues just as other forms of financing have advantages. Unlike other financing, however, leasing involves no dilution of ownership or control; it necessitates no periodic clean up of funds or pledge of receivables. Ordinarily, only the lease rental payments due within one year will appear on the balance sheet. The portion due beyond one year will usually appear only as a footnote.

Since the trend in foundries is markedly in the direction of leasing it may be of value to discuss how leasing works; and in dollars and cents see *why* some companies in the foundry industry lease equipment.

How To Lease

There is nothing complicated about leasing. The foundry deter-

mines exactly what equipment is needed, its costs and supplier—and the tenure of the lease desired. Leases may be written on straight line, declining balances, sum of the digits, or any other schedule tailored to suit the lessee's requirements. Lease plans are arranged for periods ranging from one to ten years. Normally, renewal options are available for extended periods.

Total cost of the lease is the original cost of the equipment or facility plus moderate leasing charge for the term of the lease.

Leasing permits expansion or modernization without dependence on a company's established banking connections or alternative lines of credit.

Inasmuch as only the lease payments due within 12 months appear as a liability on the financial statement, the ratio of current assets to current debt, as well as the ratio of net worth to total debt are affected very little.

While leasing is relatively simple, the easiest method by which a foundry may acquire new equipment is to take the cash out of its working capital and make the purchase with it. Yet, despite the fact that this is simpler, some foundries prefer to lease. Why?

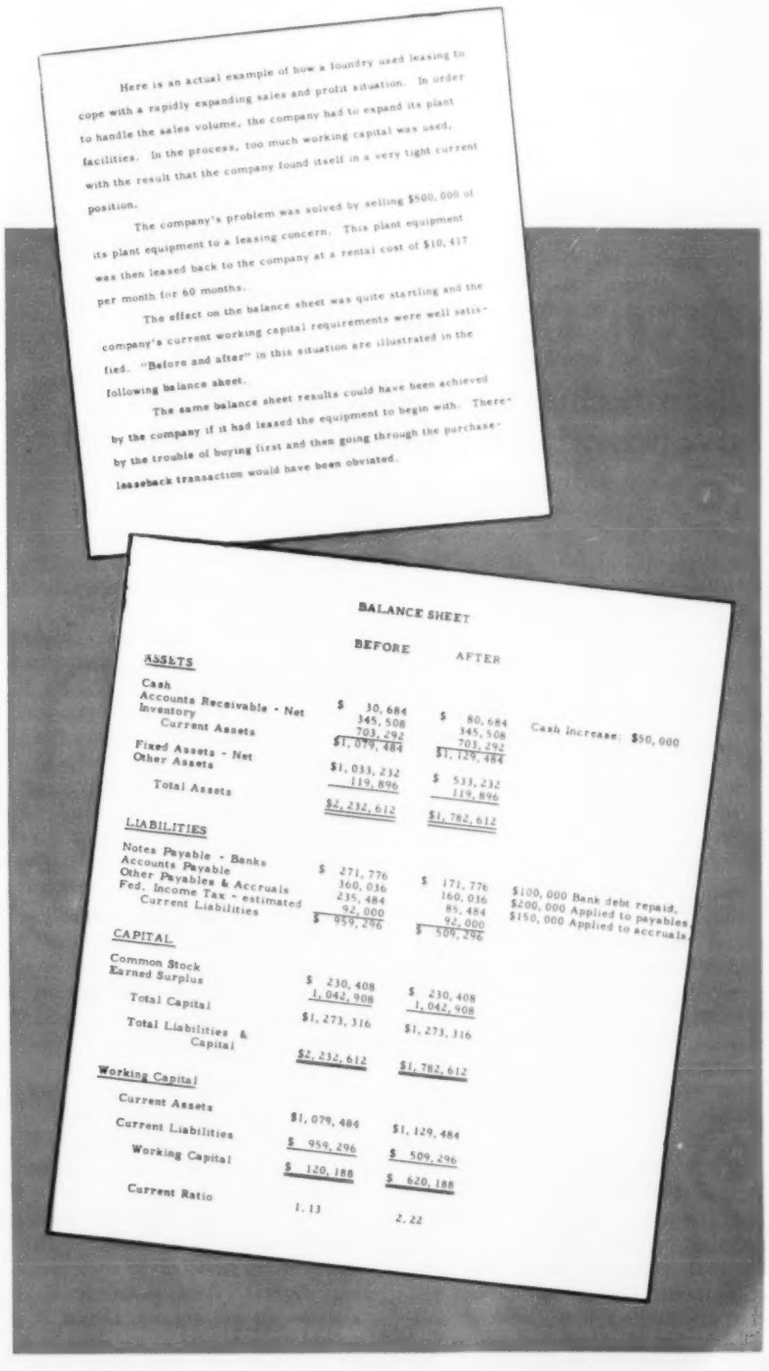
RELATIVE COST

It may cost less to lease equipment than to own it outright

The answer lies in the relative cost figures. For example, a foundry takes $10,000 out of its working capital (or a multiple thereof) and uses it to acquire new equipment. It is obviously paying something for the use of that money, since every dollar of working capital has earning power. The investment of $10,000 in new equipment must return to the company *at least* the same profit which the company can earn with this $10,000 in other ways.

How much does the typical foundry earn on working capital? It earns 19.29 per cent net profit on net working capital according to Dun & Bradstreet average earnings for net working capital in the industry (see: *Twenty-Five Years of the 14 Important Ratios*, Dun & Bradstreet, 1957, p. 60).

It is important to bear in mind that the 19.29 per cent refers to profits *after* taxes. Since all of the corporations in the sample are in the 52 per cent bracket, the profit *before* taxes on net working capital is approximately double the figure cited. Therefore, the typical



Here is an actual example of how a foundry used leasing to cope with a rapidly expanding sales and profit situation. In order to handle the sales volume, the company had to expand its plant facilities. In the process, too much working capital was used, with the result that the company found itself in a very tight current position.

The company's problem was solved by selling $500,000 of its plant equipment to a leasing concern. This plant equipment was then leased back to the company at a rental cost of $10,417 per month for 60 months.

The effect on the balance sheet was quite startling and the company's current working capital requirements were well satisfied. "Before and after" in this situation are illustrated in the following balance sheet.

The same balance sheet results could have been achieved by the company if it had leased the equipment to begin with. Thereby the trouble of buying first and then going through the purchase-leaseback transaction would have been obviated.

BALANCE SHEET

	BEFORE	AFTER	
ASSETS			
Cash	$ 30,684	$ 80,684	Cash increase: $50,000
Accounts Receivable - Net	345,508	345,508	
Inventory	703,292	703,292	
Current Assets	$1,079,484	$1,129,484	
Fixed Assets - Net	$1,033,232	$ 533,232	
Other Assets	119,896	119,896	
Total Assets	$2,232,612	$1,782,612	
LIABILITIES			
Notes Payable - Banks	$ 271,776	$ 171,776	$100,000 Bank debt repaid.
Accounts Payable	360,036	160,036	$200,000 Applied to payables
Other Payables & Accruals	235,484	85,484	$150,000 Applied to accruals
Fed. Income Tax - estimated	92,000	92,000	
Current Liabilities	$ 959,296	$ 509,296	
CAPITAL			
Common Stock	$ 230,408	$ 230,408	
Earned Surplus	1,042,908	1,042,908	
Total Capital	$1,273,316	$1,273,316	
Total Liabilities & Capital	$2,232,612	$1,782,612	
Working Capital			
Current Assets	$1,079,484	$1,129,484	
Current Liabilities	$ 959,296	$ 509,296	
Working Capital	$ 120,188	$ 620,188	
Current Ratio	1.13	2.22	

foundry earns about forty per cent annually on its net working capital before taxes.

Every company head in the foundry business is faced with this problem: If his funds earn 40 per cent before taxes and he uses working capital to buy new equipment, then he is paying 40 per cent for the use of money tied up in equipment. This is without regard to the effect of depreciation. Should he do it?

Advantages

Leasing is most beneficial for those companies whose operations could expand profitably if additional working capital, in the form of equipment and machinery, were available at smaller annual expense than through use of their own capital.

The tax advantage in leasing is debatable. Actually, the advantage of the lease arrangement lies principally in the way it frees dollars, otherwise invested in ownership of fixed assets, for more profitable uses.

Leasing offers other possible advantages. Some companies would like to convert fixed assets into current assets. So they sell the asset for cash and immediately lease it back.

Other companies are faced with a competitor who is using the latest equipment, while they themselves are lagging behind and competitor's sales increase

Acquisition of new machinery is a must, but financial ratios may not permit outright purchase, or purchase on a conditional sales contract, or even bank borrowing to make the purchase. Leasing offers a tested expedient to accomplish the end desired.

Some companies hold a tight checkrein on capital expenditures and financial ratios, although the president or division manager may feel it mandatory that certain new equipment or facilities be installed. Even if the equipment is purchased on credit plan, it decreases the ability of the concern to borrow in other directions.

The leasing of a fixed asset has a similar affect, but only to the much smaller extent of the annual rental. As a result, leasing meets the problem of the tight checkrein on capital spending or financial ratios —without forcing the board of directors to increase the capitalization of the firm.

OBSOLESCENCE

When technology is making rapid advances, it may be safer to lease

Certain companies do not like to face the problem of large equipment investments when there is a strong possibility of rapid obsolescence. Leasing by-passes the problem of large investment in such equipment and permits a user to acquire the latest and the best on a short-term lease.

Also, the whole problem of inflation has begun to cause some soul searching in corporate treasurers' offices. For many years, corporations have thought nothing of renting real property, but yet insisted on purchasing machinery and equipment. Due to inflationary pressures, industrial real estate has not only held its value in most instances, but has actually enhanced. Machinery and equipment, on the other hand, must always depreciate in value as the equipment wears out.

If the corporation expected to expend $2,000,000 on plant and a like amount on equipment, might not that company be wiser to own its real property and lease the equipment? Many corporations today are finding that the high toll of inflation is causing them to readjust their thinking as to which fixed assets should be purchased and which leased.

Finally, the desire to maintain business liquidity has led many companies to lease instead of buy. In the foundry business, the ratio of "quick assets" to current liabilities dropped from 3.44 in the middle of 1954 to 2.82 in the middle of 1957.

This decline of liquidity is in part due to the impact of federal tax legislation providing for a speed-up of corporate tax payments. In part is is also due to the greater demand for credit by business customers. The upshot is that many foundries have turned to leasing, thereby conserving working capital.

It is important, therefore, that a foundry examine its own particular situation and determine what the investment of its working capital in equipment would cost. If outside financing through leasing can be acquired at less cost than the foundry's use of its own working capital, then certainly it is sounder to use leasing. If not, it is sounder to buy.

Past, Present, and Future of Leasing

Leasing of income producing equipment is said to have started back in New York State in 1845, when the Schuykill Navigation Co. purchased transportation barges to lease to operators who wanted to use them without having to spend their own capital. Although leasing is an old idea, its current popularity is rapidly increasing. Leased metal forming and machine tools constitute 2 per cent of the total units used in industry, about $180,000,000 worth. Most of this total developed during the past eight years, and it is predicted that the total will double during the next four years.

SAVING LIVES

CARTER DELAITTRE /
Works Manager
Minneapolis Electric
Steel Castings Co.
Minneapolis

Safety contests conducted by AFS Twin City Chapter combat apathy of labor and management

Plant safety doesn't just happen —it's not that easy!

The AFS Twin City Chapter knows this is true. Four years of plant safety contests involving member foundries have demonstrated that the struggle for safer operations is a long drawn-out one. Lost-time accidents result almost one hundred per cent because of apathy regarding safety on the part of the individual employee. But where this is true, it's a good bet that this lack of interest is shared by management.

The key to future improvement in accident frequency and severity is in the hands of the *top man* in each company. When this man sincerely shoulders the responsibility of safe operations, takes a vitally active interest in safety and places safe operations as a top objective, then and only then will our safety programs take on their proper degree of importance.

Awards stimulate interest.

The AFS Twin City Chapter recognizes the importance of safety. We realize that safety is BIG BUSINESS; and that substantial savings in life, limb and money accrue to the accident-free plant.

In 1954 we set about to determine the causes and effects of accidents in member foundries in our area, with an eye to stimulating interest in our Twin City safety program. The program has consisted of a yearly safety contest among AFS member foundries. We are now into our fourth contest.

Twenty foundries participated in the first contest (1954-1955). In the two succeeding contests, 30 foundries took part.

During each contest, which runs from Nov. 1 of one year to Nov. 1 of the following year, participating foundries submit to the Chapter Safety Committee information as to hours of exposure, number of lost-time accidents, number of lost-time days and a description of each accident.

We provide monthly contest standing tabulations and accident reports to each foundry on the basis of this information. At the end of the contest a final-standings report is issued and an accident analysis report is presented to all participating foundries. At the close of each contest the Chapter presents safety award plaques to foundries with accident frequency records of ten or lower. Some foundries have recorded no accidents and receive a special award for excellence.

We feel that this contest award system has contributed greatly to an increased interest in the Chapter's safety program.

The figures for the contest ending Nov. 1, 1957, Table 1, portray some interesting facts. Of particular significance are the "accident severity" and "accident frequency" columns of the table. In both instances the figure is considerably higher for foundries with a total production figure of less than 10,000 man-hours per month as against foundries working over 10,000 man-hours per month. A comparison of "frequency" and "severity" figures for all foundries participating in each of the three safety contests appears in Table 2.

You may ask, "Why so little improvement in frequency and severity of plant accidents under our formal safety program?" True, the results of our first three contests fail to show the drop in frequency and severity we want and should expect. As mentioned earlier, safety is not an overnight accomplishment. It is rather a job of breaking down the icy reception to safety exhibited by both employees and managerial personnel. Ours is a job of stirring management to shoulder the responsibility of plant safety and to *take positive action.*

We feel, figures notwithstanding, that interest in safety is slowly taking hold. The duty lies primarily with management. Foundries participating in the contest recently ended reported 132 lost-time accidents. We feel that better supervisory guidance could have prevented all of these accidents.

TABLE 2 — COMPARISON OF THE THREE AFS TWIN CITY CHAPTER SAFETY CONTESTS

Contest	Accident Frequency	Accident Severity
1954-1955	19.6	190.5
1955-1956	34.5	2100*
1956-1957	27.3	250
1957-1958 (1st four months)	19.3	5550*

*Rates high because of accidents resulting in death.

Upon close evalution of the 1956-1957 accident reports, the following conclusions were made:

1) Unsafe acts on the part of employees were responsible for 110 of the 132 accidents.
2) Unsafe conditions caused 13 of the total.
3) Five accidents resulted from a combination of conditions and actions.
4) The cause of four accidents was undetermined due to inadequate information.

Foot and toe injuries headed the list, accounting for 28 per cent of the total. Following, in order of frequency, were: hand and finger, back, leg, metal burns, arm, eye, head injuries and miscellaneous.

In our case, the results on paper do not back up our efforts. However, we feel that we are more than half-way there and do not intend to give up. We've seen interest in safety begin to take hold during the past three years and the AFS Twin City Chapter intends to keep plugging. We're confident that in the near future our safety program is going to make some definite inroads into the lost-time accident rate facing foundries in our area.

TABLE 1 — AFS TWIN CITY CHAPTER SAFETY CONTEST TWELVE MONTH STANDINGS NOV. 1, 1956 TO NOV. 1, 1957

Hours of Exposure	No. Lost-Time Accidents	No. Lost-Time Days	Accident Severity	Accident Frequency
Less Than 10,000 Man-Hours Per Month (18 Foundries)				
1,188,462	52	483	407	43.8
More Than 10,000 Man-Hours Per Month (12 Foundries)				
3,658,102	80	726	199	21.90
Combined Totals (30 Foundries)				
4,864,564	132	1209	250	27.25

SAVING TIME

For rapid and accurate duplication of patterns many man-hours can be saved with epoxy resins.

LEONARD A. DODGE
Rezolin, Inc.
Santa Monica, Calif.

If you need to duplicate a wood pattern, epoxy resins may speed the job to completion with the expenditure of as little as 3.75 man-hours of effort. A pattern duplicate could be requested late one day and be delivered before noon the next. Patterns produced by this process have excellent surface-wear resistance and a surface smoothness limited only by the paint used for coding.

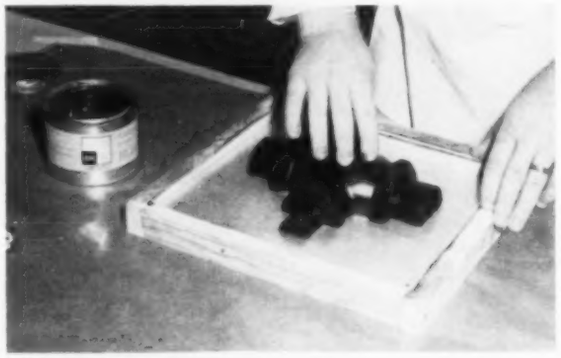
The feasibility and value of epoxy resins for tooling applications and specifically for the making of foundry patterns are already well established. This acceptance is not based on novelty but upon certain very definite cost-saving features. Some of these are labor-cost savings in the actual fabrication of the pattern; greater production life of the pattern because of high wear resistance; plus greater production per foundry man-hour resulting from lighter weight and a surface which permits better parting from sand.

However, the most practical and economical fabrication techniques are not so well established. In fact, there has been a fair amount of confusion resulting in discouraging results for some new users. The reasons for this past confusion are now quite clear. In the beginning the plastic suppliers were not completely aware of the specific problems of the patternmaker. Materials and fabrication techniques found successful in other tooling fields could not be transferred verbatim to patterns. In many cases the inherent handling characteristics of the available plastic materials made them unsatisfactory for pattern work.

The following discussion is not intended to sell the value of tool

STEP 1 — 3:30 pm Monday. Damaged pattern has been stripped to bare wood. The patternmaker is patching surface gouge with quick-setting epoxy. Patch cures overnight and is sanded to pattern contour. Total labor required is one man-hour.

STEP 2 — 9:00 am Tuesday. Thin coat of casting epoxy fills minor surface defects, imparting a high gloss to pattern. Quick-set hardener added to resin and 100 F temperature will set the coat in 3-4 hr. Labor for this operation is 1/2 man-hour.

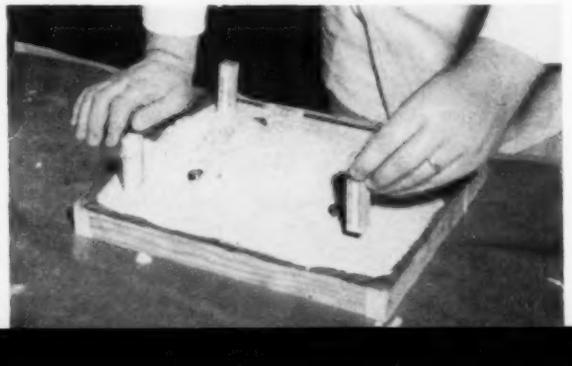


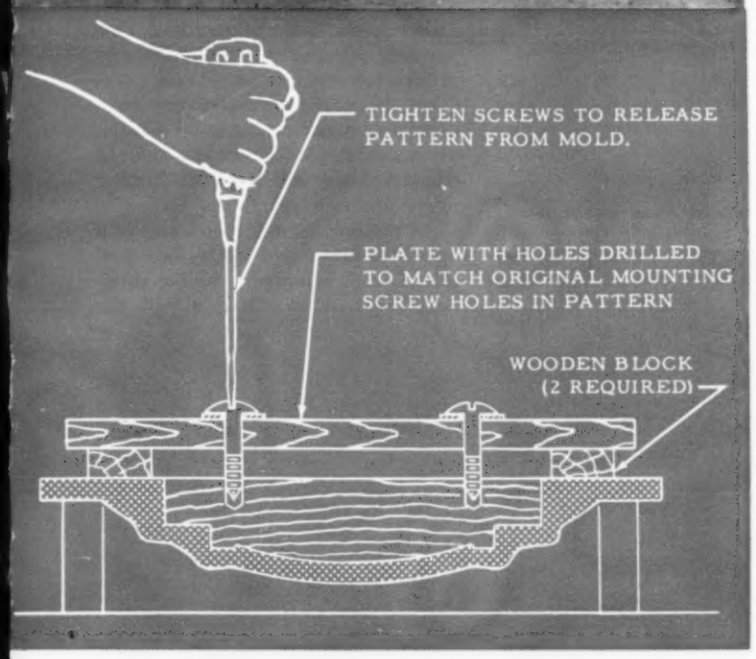
STEP 3 — 1:00 pm Tuesday. Pattern mounted with wood screws on aluminum or steel plate, minimum thickness, 1/4-in. Simple wooden dike fitted around base plate retains resin. Pattern, base plate, dike coated with mold-release. Labor, 1 man-hour.

STEP 4 — 2:00 pm Tuesday. Surface coat epoxy brushed onto pattern and base plate. Four pipe nipples, 3/8-in. ID, are pressed through coat against base plate for use in closing the mold during casting operation. Labor required, 1/4 man-hour.

STEP 5 — 2:15 pm Tuesday. Mold material mixed, using one part laminating epoxy to two parts No. 16 mesh organic aggregate. Mold mix is troweled onto pattern and base plate to a thickness of approximately 1/2-in. Labor is 1/4 man-hour.

STEP 6 — 2:30 pm Tuesday. While mix is still soft, four wooden blocks are embedded into it to form a supporting structure. The mold cures overnight and the base plate is then removed in the morning. The total labor required is 1/4 man-hour.



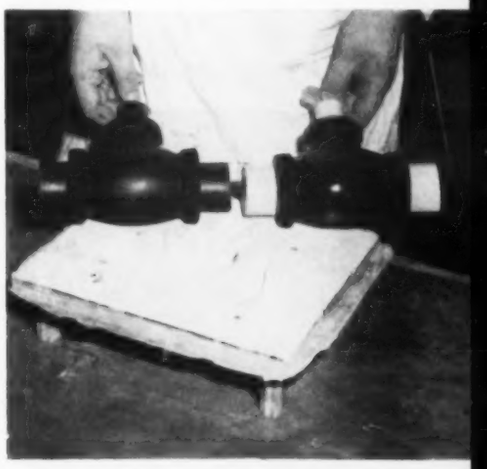

TIGHTEN SCREWS TO RELEASE PATTERN FROM MOLD.
PLATE WITH HOLES DRILLED TO MATCH ORIGINAL MOUNTING SCREW HOLES IN PATTERN
WOODEN BLOCK (2 REQUIRED)

STEP 7 — 8:30 am Wednesday. Because of low linear shrinkage of properly formulated epoxy tooling compounds, a tool is needed to extract the original pattern from the cured mold. The sketch illustrates application of tool to draw wood pattern from plastic mold. Total labor required is 1/4 man-hour.

STEP 8 — 8:45 am Wednesday. To prepare mold for casting, 5/8-in. hole is drilled in center of base plate to serve as sprue and six 1/4-in. holes drilled for risers. Four 1/4-in. holes are drilled in the base plate to match mold nipples and to lock plate to mold. Long, 1/4-in. stove bolts, washers and wing nuts used to close mold. Two 1/4-in. stove bolts inserted in screw holes after pouring, making threaded holes in epoxy casting; bolts will be used to remove duplicate pattern from mold. Release agent needed before casting. Labor, 1 man-hour.

STEP 9 — 9:45 am Wednesday. Base plate bolted to top face of mold. Sprue (0.005-in. acetate) sealed in place with clay, also used to dike around riser holes. Epoxy poured up to 1/4-in. in all risers. Two short stove bolts inserted in screw holes and casting cures in mold overnight. This job uses 2.5 lb of resin. Total labor, 1/2 man-hour.

STEP 10 — 8:30 am Thursday. Bolts are removed and base plate struck with rubber mallet to loosen plate and shear off sprue and risers. Projections trimmed. Pattern removed from mold as in Step 7. Since parting plane has been retained by duplication, the pattern is dimensionally completed. Labor required for operation, 1/4 man-hour.



STEP 11 — 8:45 am Thursday. The finished pattern is then painted according to the AFS standards and pins installed. Completed epoxy duplicate pattern is shown on right and the original wood pattern on left. Labor required is 2 man-hours.

plastics but rather to outline a simple method of making epoxy patterns requiring a minimum utilization of power tools and skilled labor.

The process illustrated was begun at 3:30 pm on a Monday and the completed pattern half was ready for use on Thursday of the same week. The total labor time consumed was 7.25 man-hours. Of this time, 3.5 man-hours were used in the repair of the original pattern and the making of a mold which would not be necessary if more patterns were required. The only power tool used was a drill press and the labor was "semi-skilled."

The procedure developed here lends itself best to the making of relatively small patterns where the weight gained from the use of an epoxy material having a density of 0.072 lb per cu in. does not create a handling problem. It might also be noted that as the pattern size and displacement increase so does the total cost of material. A point is finally reached where the increased man-hours required to produce a laminated shell with aggregate core pattern represent less dollars than the use of extra casting epoxy simply to displace air.

The particular pattern used for this illustration is half of an already used and damaged split-globe-valve pattern. The same general procedure could be followed in the duplication of a new wood or plaster master with the exception that the patching operation would be unnecessary. The core box for this pattern could be easily duplicated by the same procedure working from a plaster or wood core stick.

SAVING SPACE

Large castings cool outside on flat cars while floor space is freed for more productive use

JOSEPH A. RILEY, JR. / *Foundry Engineer*
Cooper-Bessemer Corp.
Mount Vernon, Ohio

Are you tying-up valuable floor space in your foundry waiting for large castings to cool down to shakeout temperatures? This problem was solved at the Mount Vernon foundry, Cooper-Bessemer Corp., by setting molds on railroad flat cars after pouring. Loaded car is then pulled out into the yard and left to cool for periods as long as six days.

By replacing pit molding with flask molding, ramming molds with a motive sand slinger, and cooling castings on flat cars in the yard, foundry production capacity for large castings has been doubled without increasing floor space requirements. And, more than incidentally, this triple-trick has substantially reduced casting production costs.

New Production Method

Increased demands for castings and high labor costs necessitated an overhaul of our production methods. Several changes contributed materially to operation efficiency. Flasks were constructed that would fit all castings and thereby eliminate pit molding. This greatly speeded the ramming and shakeout operations. Track was laid down the center of the main molding floor for the sand slinger. Permanent pits on either side of the track hold the large molds after they are rammed.

A pattern, mounted on a cast iron plate, is positioned in the flask and the flask is rammed with the slinger. The flask is rolled over by the crane and the pattern drawn. After finishing, the cope and drag are placed together with a spacer between them. An automatic gas-fired dryer is placed on top of the mold and piped into the spacer. The mold is dried overnight and is ready for coring in the morning. All other molds small enough to fit on the cars are oven dried overnight. When the cores are set, the mold is closed, clamped, weighted, and braced to eliminate any possible mold strain.

Castings are poured in the afternoon and allowed to solidify for a maximum of 10 hr in the foundry. All molds with a combined weight of 125 tons or less for sand, flask and casting are then placed on flatcars and run out into the yard for a cooling period as long as six days, depending on the casting. Castings which can be shaken out the same night that they are poured are left in the foundry. All flasks are loaded in and out of the foundry with a small locomotive during the night shakeout shift. As soon as a casting is moved out into the yard, the floor space is again available for productive work.

When the castings are brought

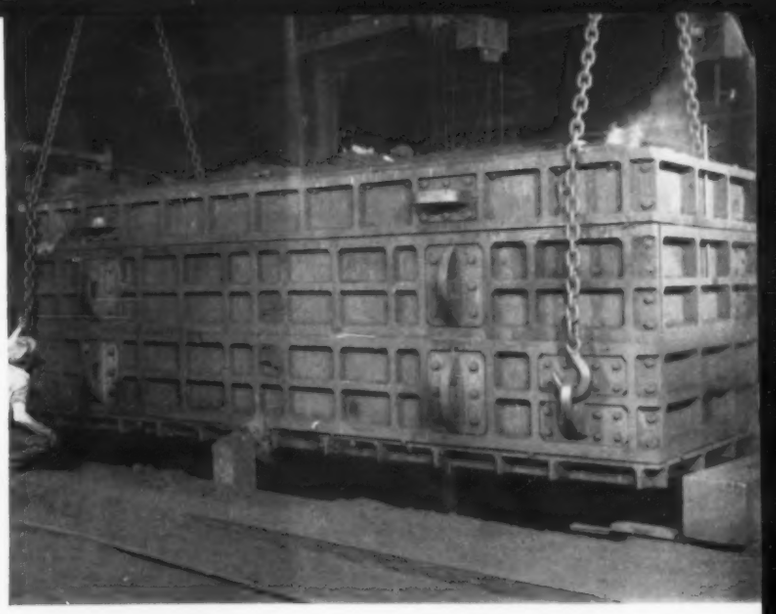
Poured-off molds with total weight of 125 tons are loaded on flat cars to cool down to shakeout temperature.

back into foundry for shakeout, cope is removed from flask and casting is lifted out. A pneumatic flask rapper is used to remove the sand from the flasks.

Savings

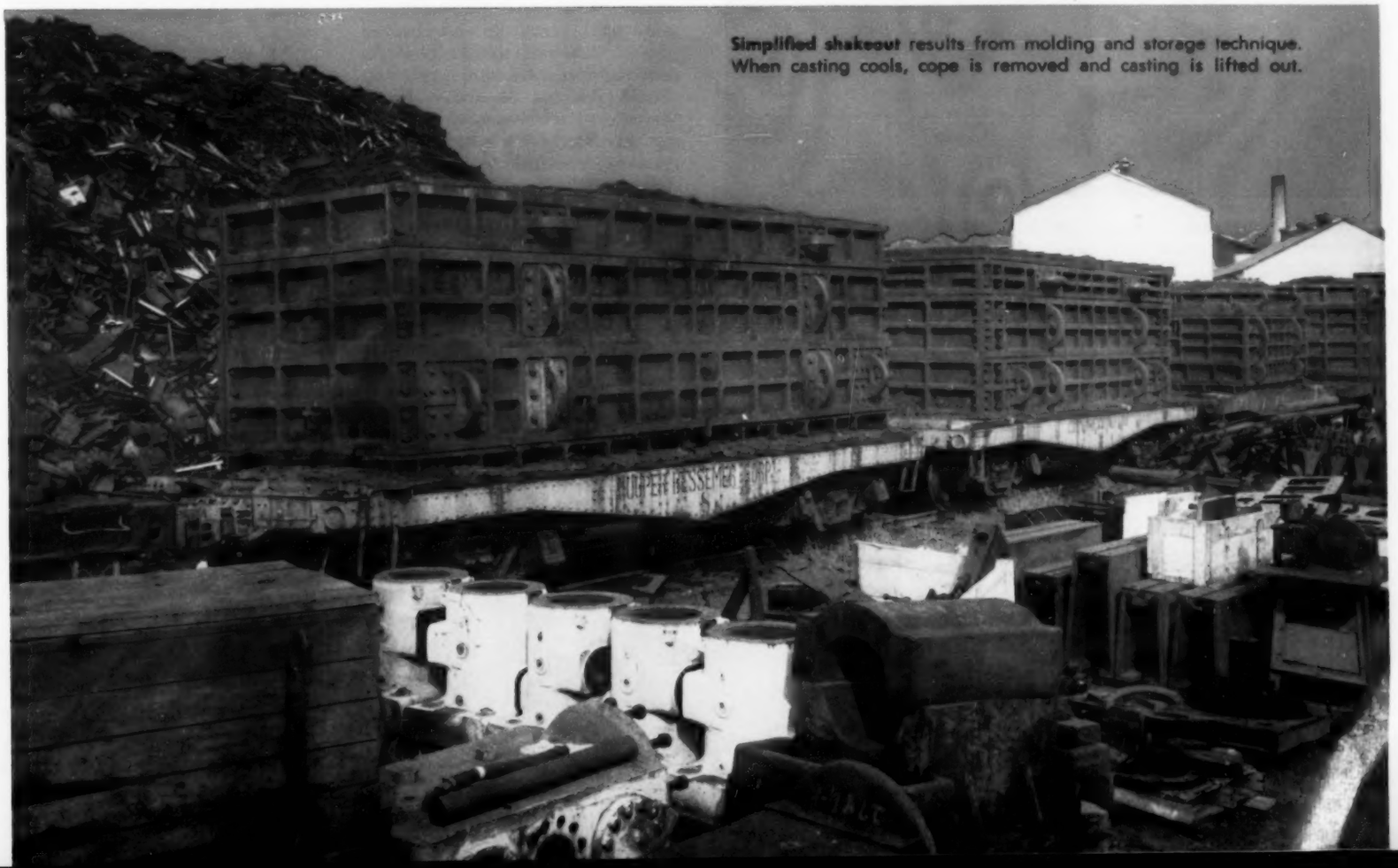
The following savings on a typical large casting have resulted from the adoption of our new production methods:

1. approximately 20 hr coremaking time by the elimination of the ram-up core used in pit molding,
2. approximately 16 hr molding time advantage of slinger ramming over hand ramming,
3. greatly simplified shakeout resulted in manpower savings in that department,
4. 100 per cent increase in production capacity without any increase in floor space requirements.



Permanent pits on either side of track down center of main molding floor hold flasks after molds are rammed.

Small locomotive pulls cars into yard where castings will be allowed to cool for periods of up to six days.



Simplified shakeout results from molding and storage technique. When casting cools, cope is removed and casting is lifted out.

A CONSUMER'S REPORT ON THE T&RI IT'S A BARGAIN!

PAUL FOGHT/*Managing Editor*

Metallography class in session with S. C. Massari at the blackboard.

This is a report on the classroom-laboratory instruction program of the AFS Training and Research Institute from the consumer's, or student's viewpoint. The study is based on observation of the T&RI course Metallography of Ferrous Metals, conducted April 16-18 at the Sherman Hotel, Chicago, and in the laboratories of Buehler Ltd., Evanston, Ill.

The report is intended as a case history to show what the 628 students who have been enrolled in the 13 courses conducted by T&RI since July 1957, have received for their tuition money.

Registration for the course began at 8:45 am at the hotel and most of the enrollees had checked in within a few minutes. Students arriving to register were greeted by T&RI Training Supervisor Ralph Betterley. Each student then picked up his study materials for the course. These included a list of his fellow students, an outline of the lectures to be given during the course, a notebook, and a MODERN CASTINGS Bonus Section on heat treating.

Only 15 minutes were allowed

FINAL EXAM

Metallography of Ferrous Metals

These questions are from the exam taken by students in the T&RI metallography course. How well would you have scored on this test?

Can element effects on alloys be determined by microscopic analysis?

Can variations in mechanical properties within a single casting be ascertained by microscopic analysis?

Is grain size in ferrous alloys directly related to cooling rate?

Can the mechanical properties of a metal be closely approximated by a micro examination?

In a gray iron of a given composition, can the mechanical properties be estimated by relative proportions of pearlite and ferrite in the matrix?

Can microstructures be grossly altered by allowing samples to become overheated during sectioning or grinding?

LAB WORK

Student Bill Oakes enjoyed the laboratory phase of the course which entailed demonstrations of equipment and preparation of his own sample.

LAB WORK **Preparation of** sample in Buehler Ltd. labs gave Bill a chance to improve his technique.

for registration and the lectures started promptly at 9:00. The few late arriving students found that they were just that, late.

Instructors for the course were Training Supervisor R. E. Betterley, T&RI Director S. C. Massari, and Professor Philip C. Rosenthal, University of Wisconsin.

Betterley and Massari eased the class into the subject and then Professor Rosenthal began to bear down.

Just as in any other school or class, a student has to check with the guy seated next to him to get a line on the instructor and on the course.

In the case of this investigation, the guy in the next chair was William Oakes, inspection superintendent, Paxton-Mitchell Co., Omaha, Neb. Paxton-Mitchell operates a ferrous and a non-ferrous foundry as well as a machine shop. Much of the work is on parts for hydraulic and pneumatic operating cylinders. Bill's job is to handle receiving and production inspection for the foundry and machine shop, and sometimes his job is to go out in the field to the customer's plant and do a little trouble-shooting.

To do his job, Bill has learned quite a lot of metallurgy and metallography. He had a year of college and had worked on statistical quality control programs before coming to Paxton-Mitchell four years ago. His knowledge of metallurgy and metallography was gleaned from the literature and from the consulting metallurgists retained by his company.

This course in ferrous metallography looked like a good way to broaden his knowledge, and learn new techniques to do a better job.

His interest in attending the course was increased by the encouragement of two other men from his company who had attended previous courses.

The lectures had just begun when Bill made a note on the varying structures of pig iron that he said would help to settle a discussion with the melting department.

Later, Professor Rosenthal delved into the mysteries of the phase diagram and Bill noted that this discussion alone made his attendance at the course worthwhile. The explanation of the diagrams, he said, made clear points which reading had never clarified.

The course was not restricted to classroom study and the second day was spent in the laboratory and demonstration rooms at Buehler Ltd. in Evanston. Turned loose on the newest types of equipment, under the guidance of Buehler engineers, many of the students demonstrated the enthusiasm of boys with a key to the candy store. Most had samples of an interesting metal from their own plant which they were anxious to prepare and examine.

This phase of the course proved to have its own values. Bill noted some improvement that he could make in the rough polishing technique he had been using in his own work.

Friday found the group back in the classroom for more lectures and a five page, 100 question exam. So, like all courses this one ended with a little sweat and anxiety.

After a student has returned home from a T&RI course he is sent a questionnaire which asks him to evaluate his experience as a student. The answers from students show that the courses are good, in fact, the courses might even be a little longer and the exams a little harder. The questionnaire that Bill Oakes returned summed up his evaluation of the metallography course with this statement, "A bargain!"

QUIZ **Final exam** calls for concentrated effort, and sometimes a point must be checked with the instructors.

FINAL REPORT

ON 62d CASTINGS CONGRESS

■ **Conclusions arising from talks delivered at the AFS Casting Congress and Foundry Show in Cleveland are presented here. These technical paper summaries cover the *Sand*, *Light Metals* and *Management* sessions. Next month, MODERN CASTINGS will publish summaries of papers relating to brass and bronze, gray iron, die casting, heat transfer and noise and radiation. The June issue of MODERN CASTINGS included summaries of talks given at malleable iron, patternmaking, steel, fundamental papers, and plant equipment sessions of the Casting Congress.**

Presiding at the Malleable Round Table Luncheon were, left, F. B. Rote, Albion Malleable Iron Co., and center, J. H. Lansing, Malleable Founders' Society. Speaker L. D. Ryan, right, spoke on diversification.

Sand

"Investigation of the Hardening of Sodium Silicate Bonded Sand," C. E. Wulff, University of Wisconsin, Madison, Wis.

Hardening of sodium silicate bonded sand can be accomplished by three methods:

1) CO_2 hardening,
2) H_2O evaporation hardening,
3) thermal hardening.

CO_2 and evaporation hardening appear to be similar. Thermal hardening is different, but in the lower temperature range of oven baking it is still a reversible process.

Long CO_2 gassing is of no advantage, and for economic reasons evaporation set is recommended. Thermal hardening produces high strengths at moderate binder percentages.

Room temperature core deterioration can be two types:

1) fracturing of binder (moisture loss).
2) softening of binder (moisture pickup).

"A Literature Review of Metal Penetration," A. E. Murton and S. L. Gertsman, Department of Mines and Technical Surveys, Ottawa, Ontario, Canada.

With low metal heads mechanical penetration can be eliminated by controlling void size (fine sands, good ramming, refractory sands, mold washes), and using low pouring temperatures. When it is necessary to use high metal heads, together with hot spots on the casting, it is difficult at present to prevent penetration with practicable sand mixures.

The tests show that attention should be paid to reducing metal head as much as possible, especially over hot spots, by gating design and the use of blind risers.

Penetration may be practically eliminated by core mixtures containing up to 100 per cent silica flour, but these mixtures are difficult to use. They are hard to mix, hard to bake, have low green and dry tensile strength, and their use is likely to result in other casting defects.

"Mold Surface Behavior," D. Roberts, Oil City Iron Works, Corsicana, Texas, and E. E. Woodliff, Detroit.

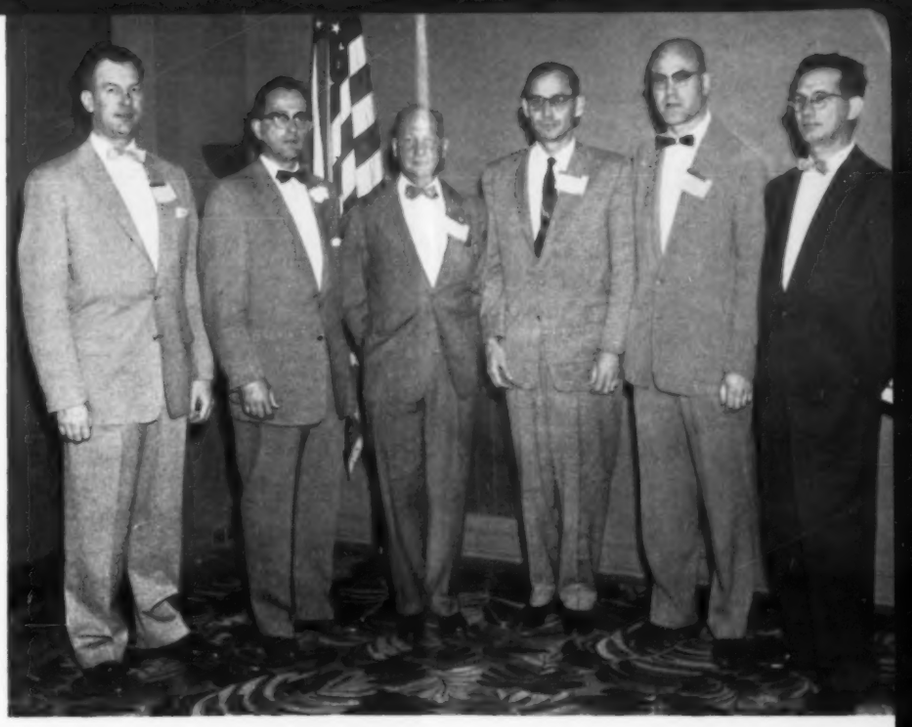
The simple measurement of sand growth as metal is cast around it offers a means of control over the many casting defects caused from its expansion. It is possible to pre-

Technical publications were sold and displayed at the AFS booth.

Dignitaries of the Steel Round Table Luncheon, left to right, E. H. Howells, A. F. Kiesler and W. R. Hibbard, discuss plans for their session.

British non-ferrous casting is explained by L. J. Brice, right, at the Die Casting Session. Officers, seated, Prickett, Hodgson and Dunn.

Brass & Bronze Round Table Luncheon group discussed copper alloys.



Right — Good sand practice was discussed at the Sand Shop Course by this panel. V. Rowell, Harry W. Dietert Co., left, presided.

determine the behavior of a sand as to its expansion characteristics by control over the several factors contributing to its expansion.

Factors found mostly influencing sand behavior are:

1) type of sand grain,
2) true clay content,
3) distribution of grains,
4) fine content,
5) combustibles type and content,
6) pouring temperature,
7) pouring rate,
8) rammed density or hardness.

While all defects are not from sand expansion, the authors conclude that the expansion meter offers a distinct advantage in control of the many causes of mold wall movement.

"The Theoretical Concepts of the Packing of Small Particles," J. B. Caine, Cincinnati, and C. E. McQuiston, Advance Foundry Co., Dayton, Ohio.

From the application of Wise's particle-packing theory to foundry sands, these general conclusions are warranted:

1) The maximum density of a foundry sand grain distribution is independent of the fineness.

Continued on page 102

Right — Planning the Pattern Luncheon which discussed castings sales, left to right, J. Kreiner, J. Roth, G. Dreher, E. Kindt and C. Bueg.

Theme of this Industrial Engineering Session was work simplification.

Experiences with a Water-Cooled Cupola at Tyler Pipe

by M. J. Henley
Tyler Pipe & Foundry Co.
Tyler, Texas

Editor's Note: *This article contains highlights excerpted from a talk by M. J. Henley presented at the 1958 Southeastern Regional Foundry Conference.*

The cupola described in this talk is externally water cooled, uses protruding copper tuyeres and has no lining except in the well.

■ LENGTH OF HEAT – We have operated this cupola continuously for as long as 15 days, 24 hr per shift . . . . It could probably be operated indefinitely or at least as long as one to two months continuously – especially if equipped with two tap holes . . . . This furnace can also be operated on 16-hour campaigns with a bankover of 8 hours or longer for as long as 6-8 weeks before dropping bottom.

■ OPERATING ACID, NEUTRAL OR BASIC – With no lining in the stack and a carbon lining in the well, it is practical to operate acid, neutral or basic within the same campaign producing the desired quality of iron.

■ RAW MATERIALS – We can melt all cast scrap or all steel scrap or any combination thereof . . . . If using 100 per cent steel scrap, at least 80 lb of coke per ton of steel is needed to raise the carbon content to 3.80 per cent. . . . No pig iron has been used in our operation for the past 3 years.

■ FLUID IRON – When operating neutral or basic and more particularly basic, you can obtain iron near the eutetic point if the phosphorous content is low . . . . We have poured 1/8-in. sections with 0.05 per cent phosphorous iron with excellent fluidity . . . . This iron has an excellent chance of replacing high phosphorous stove plate iron.

■ SAVE MANGANESE – In cold blast acid cupola operation one normally loses 20-23 per cent of the manganese charged . . . . In a basic operation manganese loss will be 3 per cent and under . . . . Manganese oxide in the slag on a very basic operation will be 0.5 per cent or less.

■ SILICON LOSS – When operating basic it is normal to think that the high silicon loss (18-30 per cent) is a disadvantage . . . . However, the very high resultant carbon equivalent iron will offset the 20 per cent silicon loss . . . . If normally operating with a 2 per cent silicon iron you might use a 1.80 per cent silicon iron, since the carbon will be in excess of 3.70 per cent . . . . The iron will still be fluid and gray in thin sections . . . . If a water-cooled acid or basic cupola is operated with preheated air of 900-1100 F the silicon loss will be nil.

■ REFRACTORY COST – Refractory cost for a water-cooled cupola operated basic will average approximately 13 cents per ton melted – repair cost, not installation cost . . . . For a conventional acid-lined cupola the refractory cost will vary from 25 to 50 cents per ton melted, depending on the length of heat.

■ CONSTANT MELTING ZONE DIAMETER – This is of great advantage in determining the coke splits necessary to maintain the proper bed height – particularly in the latter part of a long heat.

■ DUCTILE IRON – When operated sufficiently basic to produce sulphur under 0.01 per cent and iron oxide below 0.05 per cent, the resultant iron is an excellent base for ductile iron . . . . I am familiar with a company that produces ductile iron with as low as 8 lb of 8 per cent magnesium alloy per ton of iron treated (sulphur 0.006 per cent).

■ PRE-MELT FOR STEEL – This is an excellent furnace for a duplex system to produce steel since you can produce low-sulphur low-phosphorous base iron.

■ CRACKING OF SHELL – We had some cracking of the shell two or three feet above the tuyere after the furnace was in operation some two years . . . . Evidently this is caused by the temperature differential in the sections above the tuyeres causing an expansion and contraction.

■ EFFICIENCY – A normal cold blast acid-lined cupola operates at an efficiency of about 32 per cent. A water-cooled acid cupola would likely operate at 26 to 28 per cent efficiency . . . . Our calculations indicate that it requires about 30 lb extra coke per ton of metal because of the temperature loss to the water (this is based on a loss of 5,000,000 to 6,000,000 Btu per hr) . . . . If you install a hot blast to heat the air 900 to 1100 F you probably could pick up 49 lb of coke per ton melted.

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INVESTIGATIONS ON THE EFFECT OF HEAT ON THE BONDING PROPERTIES OF VARIOUS BENTONITES

By
Franz Hofmann*

INTRODUCTION

Determining green strength alone, as practiced for obtaining quality characteristics of bentonites, yields little knowledge on performance of such bentonites under operating conditions. Durability of bentonites in a particular system sand cannot be ascertained.

These shortcomings led to this investigation. Results disclose considerable variations of durability between bentonites, differences which appear in practical operation.

This report also deals with comprehensive testing of bentonites for foundry uses, and with possibilities offered by differential thermal analysis.

Bentonites are clays of predominantly montmorillonitic nature. They are a transformation product of glassy volcanic ashes, mostly of acid composition. The transformation of volcanic glass into clay may have reached various degrees. This transformation took place during or immediately after a volcanic eruption, and was influenced by eruption conditions such as the presence of steam and temperature. As a rule the ejected ashes were carried over long distances by the wind, deposited in stratas and imbedded by sedimentary deposits.

One of the most important and typical properties of bentonites is their base exchange capacity. The relation bentonite-water in particular is influenced by the nature of exchangeable ions which saturate the clay.

WESTERN-TYPE BENTONITES

Bentonites which are predominantly calcium saturated correspond to the nonswelling southern type. Whereas bentonites which are sodium saturated (western type) swell to a high degree in water and form thixotropic, gelatine-like suspensions.

Calcium and sodium bentonites are found naturally in the United States. The western type, particularly the bentonites of Wyoming and South Dakota, are naturally sodium saturated because the bentonitic volcanic ashes were deposited in the sea.

Economically important deposits of western-type bentonite cannot be found in Europe and North Africa. This is because the conditions typical for the formation of Wyoming bentonite were missing. Therefore, all important and numerous bentonite deposits in the old world are specific nonswelling calcium bentonites.

In Europe, the natural calcium bentonites are frequently converted artificially by base exchange into sodium bentonites, whether for foundry uses or other applications. One such application is drilling muds for oil exploration, where a high swelling capacity is important.

For the transformation of calcium into sodium bentonite, sodium salts are used. By substitution of the clay bound calcium, these yield insoluble calcium salts. This means that the reaction takes place only in one direction. For practical purposes sodium carbonate ($Na_2 CO_3$) is used as a rule up to 5 per cent for drilling muds. The base exchange takes place only in the presence of water as follows:

$$\text{Ca-bentonite} + Na_2 CO_3 = \text{Na-bentonite} + CaCO_3.$$

FOUNDRY APPLICATION

For foundry applications the soda addition should not be too high, because soda will increase the slagging tendency of the sand. Five per cent soda corresponds to the saturation of an exchange capacity of 100 milliequivalents.

The actual base-exchange capacity of ordinary bentonites with different origin varies little, but the speed of base exchange is different. There are calcium bentonites which, in a watery suspension and after addition of soda, are converted within a few sec into a highly thixotropic gel. Other bentonites do not react at all under similar conditions. In these latter cases of slow base-exchange capacity, the exchange occurs only with boiling, drying, and rewetting.

The bentonites with a slow base-exchange capacity have a coarse particle size distribution in their natural state. The structure of the volcanic glass ash is in evidence. The particles of montmorillonite are contained as coarse aggregates. The speed of base exchange seems to be influenced by the dispersity, and by crystal structure and chemical composition. Only a

*Head of Sand Research Laboratory, George Fischer Ltd., Schaffhausen, Switzerland.

little information is available on this topic. The investigation reported here will illustrate some of the relationships.

TESTING METHODS

Determination of Bonding Capacity

To determine the bonding capacity of the bentonites, investigated mixtures of standard testing sand with 5 per cent bentonite were used. A bentonite sample of 50 grams served for determining moisture content at 105 C. Subsequently, and for making the mixture, a quantity of undried bentonite corresponding to 5 per cent dry substance at 105 C was used. Every test mixture contained 2000 grams silica sand and 100 grams dry bentonite substance. The mixtures were prepared dry for one min and wet for 5 min in a laboratory muller.

For every test three mixtures, differing in moisture content by about 1/2 per cent, were made in the range between too dry and too moist. The intermediate mixture would correspond to correct temper moisture content.

All mixtures were stored in sealed containers overnight, screened through a 6-mesh sieve immediately before testing and placed in the containers again.

The next step consisted in determining the water content of each mixture with a sample of 50 grams. This was considered important, because bentonite mixture properties are strongly influenced by the water content.

After the moisture content, the remaining properties, particularly green strength, were determined. This resulted in functional curves showing the properties concerned vs. water content. Dry strength was tested according to the AFS method.

Term and Definition—Correct Temper Moisture Content

Molding sands with correct temper moisture content are neither too moist nor too dry. They are best suited for molding. Natural molding sands with high clay content have a wider moisture tolerance for correct temper than synthetic sands containing but a small amount of binder. These latter sands react strongly to small changes in water content in regard to strength, permeability and density. They feel too wet or too dry. This is true particularly for bentonite testing mixtures.

The correct temper may be estimated accurately and reproducibly by feeling the three test mixtures of different moisture content by hand. The correct temper-moisture content may be determined in this way within 0.1 per cent. As a rule, this corresponds to the minimum bulk-density point at which the sand has the loosest formation at constant compaction work, and highest permeability.

In this connection the work done by Dietert and Valtier[1], Grim[2], and Goetz[3], should be mentioned. The properties at correct temper-moisture content may be derived graphically from the functional curves mentioned earlier.

The correct temper of bentonite mixtures lies considerably on the wet side of the water content which imparts maximum green strength. At this point, however, the sand is too dry, difficult to ram and test, and too brittle for foundry use.

The correct temper-moisture content for different bentonite types in the standard sand mixture may vary under identical testing conditions. Calcium saturated bentonites usually require more water than sodium bentonites to give the same feel of correct temper. Properties of different bentonites should not be compared at an arbitrary constant water content. For the comparison of bentonites only the properties, particularly bonding capacity, expressed by green strength measured at correct temper-moisture content should be considered.

The correct temper-moisture content of the test mixture for different bentonites in this investigation will be indicated, as well the hygroscopicity of each bentonite. This is expressed in water content at room temperature and a relative humidity of 75 per cent. The hygroscopicity is closely connected to various properties of bentonites (Hofmann[4]) as will be seen from the results.

Heat Treatment and Determination of its Influence on Bonding Capacity

First, properties were determined depending on the water content of thermally-untreated bentonites. This gave the value of the properties concerned at correct temper-moisture content and at room temperature.

Second, the whole quantity of the tested sand was dried at 100 C for 3 hr, and divided in 3 parts. Each part served for making a test mixture in the laboratory mixer at different moisture content. This yielded the properties values at correct temper-moisture content and 100 C.

Third, the same quantity of sand was treated at 200 C for 3 hr, divided and made into three mixtures of different moisture content in the laboratory muller. This gave the properties values at correct temper-moisture content and 200 C.

This procedure was repeated for 300, 400, 450, 500 C, and higher temperature to the point where the green strength of the sand was negligible after retempering.

This method of thermal treatment of the whole sand-bentonite mixture and of repeated retempering was chosen to reproduce actual reconditioning in foundry operation. It was also possible to heat a constant quantity of bentonite alone at each temperature, and to mix it afresh with standard testing sand. This procedure would not yield exactly the same results as the method described, because lack of the influence of repeated reconditioning in the laboratory mixer.

Moreover, the effect is not the same if the untreated bentonite is first mixed with the sand, or if the bentonite is first heated to 500 C and has lost a part of its plastifying capacity with water. In this connection, the author would like to point out the work done by Patterson and Boenisch[5] on the influence of mixing on the bonding capacity.

Differential thermal analysis (DTA)

Differential thermal analysis is an important method for investigating clay minerals. It consists of meas-

uring the temperature differences between a test sample and a thermally-inert reference sample, both of which are simultaneously, uniformly, and continuously heated to 1000 C. Any change in the test material results in a consumption or generation of heat. The sample becomes cooler or warmer when compared with the reference substance. If both substances rise in temperature constantly no reactions are taking place.

The endothermic or exothermic reactions are picked up by sensitive thermocouples placed in the specimen and are photographically recorded by way of a galvanometer. Downward deflections of the DTA curves indicate endothermic reactions. Upward deflections indicate exothermic reactions. In evidence are the reactions caused by the dehydration between 100 and 200 C. Molecular water absorbed in the clay and held there by hygroscopicity is evaporated.

The second endothermic reaction indicates loss of the OH-groups which are imbedded in the crystal lattice of clay minerals (crystal water). From this point rehydration, and the ability of the clay concerned to be plastified, is destroyed.

TEST RESULTS

Western vs. Southern Bentonite

The author investigated a nontreated commercial western-type bentonite from Wyoming, and a southern-type bentonite from Mississippi. These bentonites display the properties with water given in Table 1.

The bonding capacity is shown in Fig. 1. The western-type bentonite has a high thermal resistance which decreases when heated above 600 C. The bonding capacity of southern-type bentonite starts to decrease gradually after a heating temperature over 100 C.

The values for dry strength have the same trend as the green strength values. These are shown in Fig. 2. They do not differ fundamentally.

The difference of thermal resistance is the characteristic distinction between western and southern bentonites. Southern bentonite has better shake-out properties due to a faster decrease of bonding capacity. Synthetic sands with southern bentonite burn out to a higher degree during the casting operation. Conversely, the durability of sands with western bentonite is higher. Less bentonite is required to recondition such sands.

Figure 3 shows the DTA curves found for both bentonites. The difference in thermal properties is evident. With western bentonite the endothermic effect caused by loss of the OH-groups, and the final loss of bonding capacity occurs at 780 C. The decrease starts at about 650 C. With southern bentonite a continuous decrease may be recognized starting at 400 C, and ending at 720 C.

These DTA-curves generally cover the curves of bonding capacity shown in Fig. 1 and 2. They indicate how well the effect of temperature and bonding capacity is expressed. The bonding capacity is actually affected somewhat earlier than the deflections of the DTA curves.

The quantity of bonding water required for correct temper of sand rises with increasing loss of bonding

TABLE 1 – BENTONITE PROPERTIES WITH WATER

	% Western	% Southern
Hygroscopicity	8.2	11.5
Initial correct temper moisture content	2.1	2.0

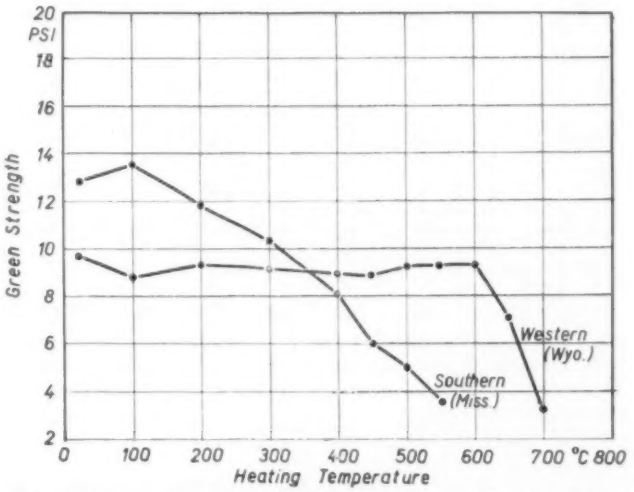

Fig. 1—Green strength vs. heating temperature for U.S. Western (Wyoming) and Southern (Mississippi) bentonite. 5 per cent bentonite, 3 rams, temper moisture content.

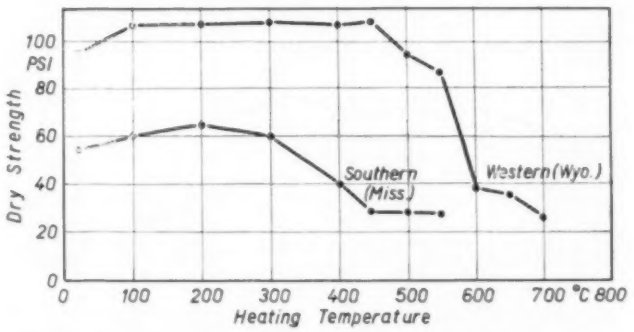

Fig. 2—Dry strength vs. heating temperature for U.S. Western (Wyoming) and Southern (Mississippi) bentonite. 5 per cent bentonite, 3 rams, 105 C, 2 hr.

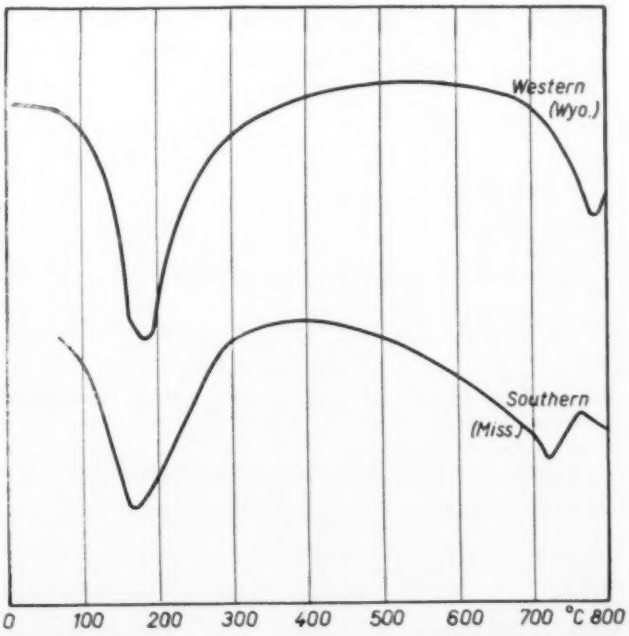

Fig. 3—Differential thermal analysis curves for U.S. Western and Southern bentonite.

capacity. Figure 4 shows this relation for both American bentonites investigated, and indicates that the green density for three rams changes simultaneously. This figure makes clear to what extent rammed molding sands properties are a result of the relationship between water content and green density (Gotz[3]).

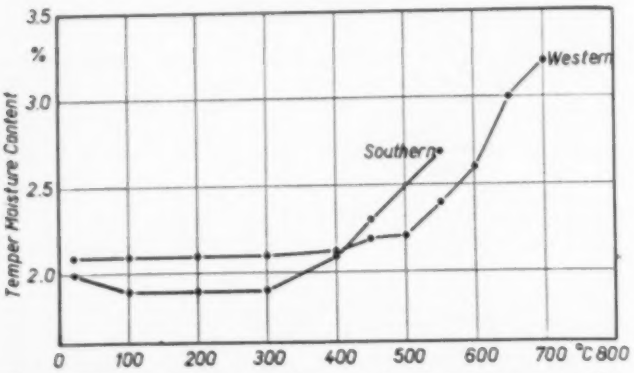

Fig. 4—Temper moisture content vs. heating temperature for U.S. Western (Wyoming) and Southern (Mississippi) bentonite. 5 per cent bentonite; moisture content after retempering heat treated test mixture.

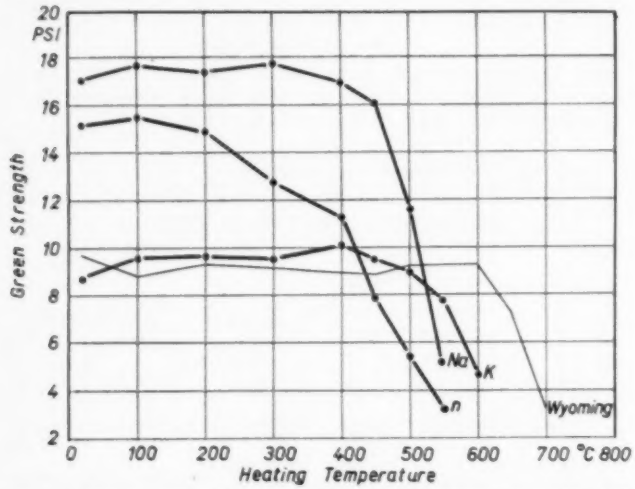

Fig. 5—Green strength vs. heating temperature, investigated for Swiss bentonite: n = natural state, Na = treated with 3 per cent sodium carbonate, K = treated with 4 per cent potassium carbonate. Wyoming bentonite shown as reference material. 5 per cent bentonite, 3 rams, temper moisture.

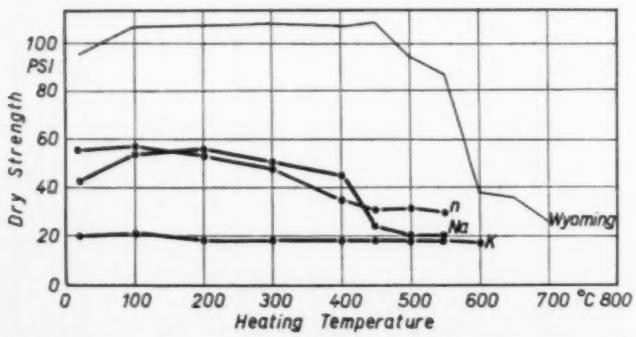

Fig. 6—Dry strength vs. heating temperature, investigated for same bentonites as with Fig. 5. 105 C, 2 hr.

TABLE 2 – SWISS BENTONITE PROPERTIES WITH WATER

	% natural	% Sodium treated	% Potassium treated
Hygroscopicity	15.0	9.0	8.0
Initial correct temper moisture content	2.6	2.3	2.3

Swiss Bentonite

The Swiss bentonite used is, in the natural state, of coarse particle-size character. It is a nonswelling Ca-bentonite. A pipette analysis showed about 10 per cent particles finer than 20 microns.

For the purpose of this work, the author investigated the bonding capacity of this bentonite in its natural state. This test was made after treatment with 3 per cent sodium carbonate ($Na_2 CO_3$), and treatment with 4 per cent potassium carbonate ($K_2 CO_3$). In a watery suspension this bentonite did not react after adding the alkaline salts. It has a slow base exchange capacity. Only after heating the suspension with alkaline carbonate is it transformed into a sodium or potassium bentonite.

The suspension treated with sodium or potassium carbonate was evaporated at 100 C. The residue was then rewetted and dried again. After this treatment the sodium bentonite obtained corresponded to a typical high-swelling western-type bentonite, although swelling capacity is not as high as that of Wyoming bentonite.

The bentonite types investigated show the properties with water given in Table 2.

Hygroscopicity is reduced by alkaline treatment as well as quantity of water required for correct temper. This is in despite of the higher swelling capacity. Sodium bentonites swell only in an abundance of water. The sodium treatment causes the individual particles to be finely dispersed, and to reject each other in a watery suspension. They form a thixotropic gel, whereas calcium ions cause a coagulation of the bentonite particles. Nevertheless, calcium bentonites are stronger hydrated than the sodium bentonites without a surplus of water. This has also been found by R. E. Grim[6]:

> "Numerous investigations have brought out the interesting fact, that Na montmorillonite, on drying at room temperature, tends to develop a single water layer between the silicate layers and that Ca montmorillonite under the same conditions tends to develop two water layers, whereas, at high relative humidities and in the presence of an abundance of water, Na montmorillonite absorbs by far the larger quantity of water."

To find the correct bonding temper of a foundry sand, the bonding bentonite does not require a water surplus. It requires an amount of water corresponding to approximately one-half of the bentonite weight. In this case swelling capacity has no effect.

On the other hand, swelling capacity plays its part in a bentonite slurry. In this case only 10 per cent sodium bentonite may be suspended in water, if this suspension is to remain liquid. Forty per cent calcium bentonite may still produce a slurry which can be poured well.

The influence of alkaline treatment on bonding capacity is shown in Fig. 5 and 6. An untreated Swiss bentonite reacts practically in the same manner as the American southern bentonite. Sodium treatment does not cause a decisive increase of the temperature to where the final loss of bonding capacity occurs. The rate of loss of bonding capacity of the natural bentonite is improved by sodium carbonate. Dry strength

is not essentially altered by sodium. In contrast, potassium carbonate causes a drop in green strength and dry strength. The residual bonding capacity is maintained over a large range with decreasing temperature.

The DTA-curves in Fig. 7 show that the point of final destruction of bonding capacity cannot be shifted by alkaline treatment. The continuous decrease of bonding capacity with natural bentonite, and the improvement of its behavior by sodium treatment, clearly affect the trend of the curves. The difference in thermal resistance expresses itself in a typical manner in comparison to the DTA-curves in Fig. 3.

Mediterranean Bentonite 1

Similar to Swiss bentonite, Mediterranean bentonite in its natural state is a nonswelling southern-type bentonite of brown color. It has a lower rate of base exchange, and only by repeated evaporation and rewetting may be converted into a sodium bentonite of medium swelling capacity.

With water Mediterranean bentonite has the characteristics given in Table 3.

Figure 8 and 9 show the behavior of bonding capacity of Mediterranean bentonite corresponding to data in Table 3.

The rate of loss of the initial high green strength is high with rising temperature as it is with Swiss bentonite. By sodium treatment this loss rate is somewhat diminishing without the final temperature of destruction raised. The influence of sodium treatment is less convincing with this bentonite of slow base exchange capacity. Correspondingly, the DTA-curves (Fig. 10) hardly differ.

Mediterranean Bentonite 2

This bentonite in natural state is a nonswelling type also. In contrast to the Mediterranean type 1, and Swiss bentonite, it has a naturally fine particle-size character. It distinguishes itself by having a high speed of base exchange. If 3 per cent sodium carbonate is added to a well-pouring suspension of this type natural bentonite, the conversion to sodium bentonite takes place within a few sec. A stiff gel is formed from a liquid suspension.

Properties of this bentonite with water are those given in Table 4.

Figure 11 and 12 show that even in the untreated state the drop in bonding capacity of this bentonite with increasing temperature is not as marked as with the bentonites described in Figs. 5 through 10. By sodium treatment, thermal resistance and absolute strength values are lifted to a level so that this bentonite does not differ essentially from an American western-type bentonite.

Mediterranean Bentonite 3

Of all bentonites investigated, this type has the highest speed of base exchange. This results in having the highest swelling capacity. By nature, this almost-white bentonite has a fine particle-size character, and is nonswelling.

With water, it shows properties given in Table 5.

The bonding capacity of this bentonite performs well in the untreated state with rising temperature. It is improved by sodium treatment. The temperature of

TABLE 3 – MEDITERRANEAN BENTONITE NO. 1 PROPERTIES WITH WATER

	% natural	% Sodium treated
Hygroscopicity	15.1	11.8
Initial correct temper moisture content	2.1	2.1

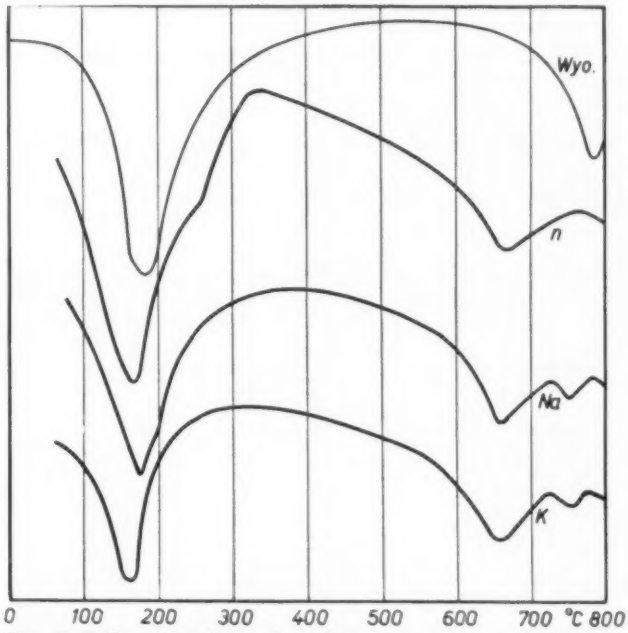

Fig. 7–Differential thermal analysis curves for Swiss bentonite: n = natural state, Na = treated with 3 per cent sodium carbonate, K = treated with 4 per cent potassium carbonate. Curve of Wyoming bentonite shown as reference.

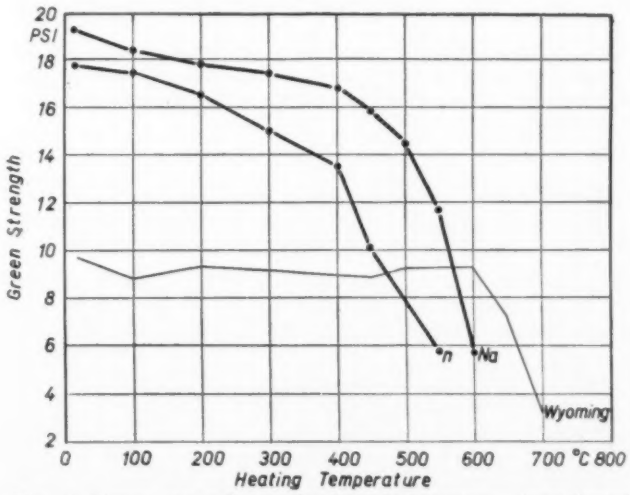

Fig. 8–Green strength vs. heating temperature, investigated for Mediterranean bentonite 1: n = natural state, Na = treated with 3 per cent sodium carbonate. Wyoming bentonite shown as reference. Five per cent bentonite, 3 rams, temper moisture content.

TABLE 4 – MEDITERRANEAN BENTONITE NO. 2 PROPERTIES WITH WATER

	% natural	% Sodium treated
Hygroscopicity	6.5	6.2
Initial correct temper moisture content	2.4	2.2

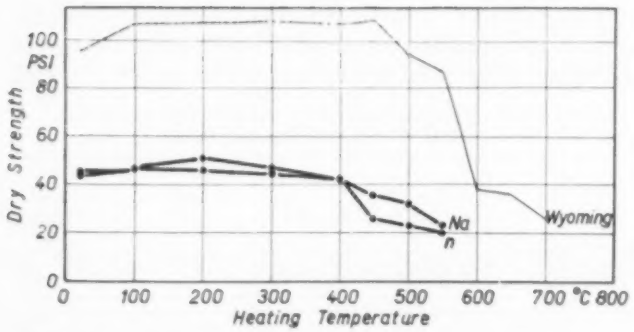

Fig. 9—Dry strength vs. heating temperature, investigated for same bentonites as with Fig. 8. 105 C, 2 hr.

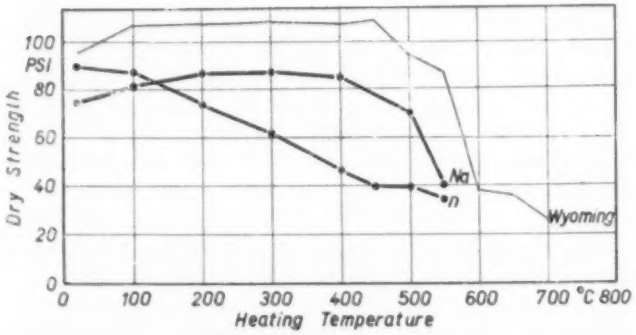

Fig. 12—Dry strength vs. heating temperature, investigated for same bentonite as with Fig. 11. 105 C, 2 hr.

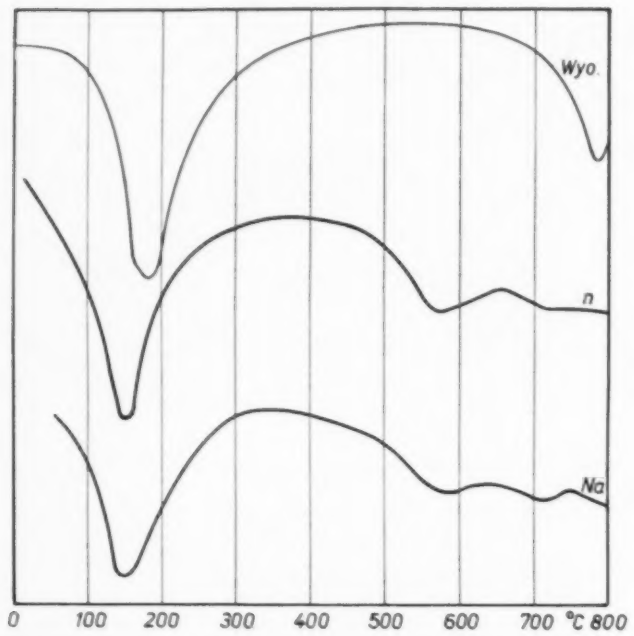

Fig. 10—Differential thermal analysis curves of Mediterranean bentonite 1: n = natural state, Na = treated with 3 per cent sodium carbonate. Curve of Wyoming bentonite shown as reference.

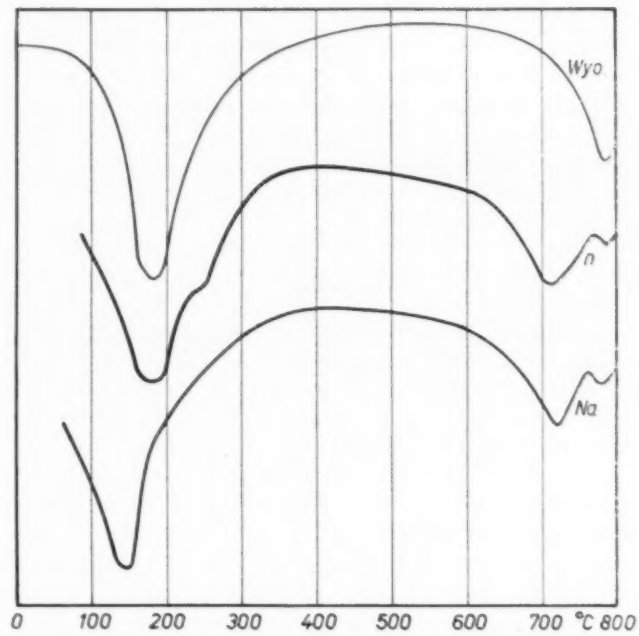

Fig. 13—Differential thermal analysis curve of Mediterranean bentonite 2: n = natural state, Na = treated with 3 per cent sodium carbonate. Curve of Wyoming bentonite shown as reference.

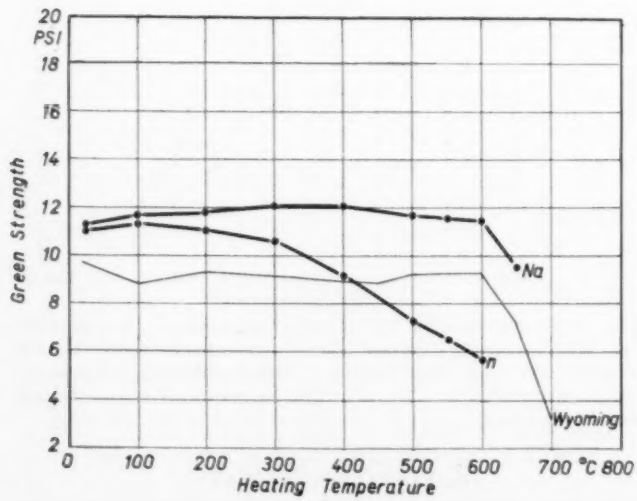

Fig. 11—Green strength vs. heating temperature, investigated for Mediterranean bentonite 2: n = natural state, Na = treated with 3 per cent sodium carbonate. 5 per cent bentonite, 3 rams, temper moisture content. Wyoming bentonite shown as reference.

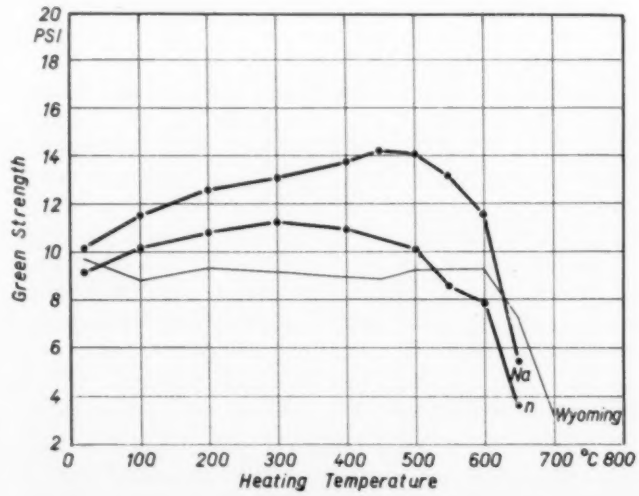

Fig. 14—Green strength vs. heating temperature, investigated for Mediterranean bentonite 3: n = natural state, Na = treated with 3 per cent sodium carbonate. 5 per cent bentonite, 3 rams, temper moisture content.

final destruction of bonding capacity remains unaltered in this case (Fig. 14 and 15). The conversion into a sodium bentonite (as in the previous cases) does not essentially change the dry strength.

Corresponding to the similar performance of bonding capacity depending on temperature, the DTA-curves of untreated and treated bentonite do not differ (Fig. 16).

CONCLUSIONS

The investigations of the author bring the following conclusions to light. They are important for the performance knowledge of bentonites as bonding agents for foundry sands.

1. Bentonites of various types may have different thermal resistance (durability, life).
2. By ion exchange, in particular by conversion of calcium bentonites into sodium bentonites by activation with sodium carbonate, the bentonite cannot be fundamentally changed. The temperature of final destruction of bonding capacity remains unaltered. In most cases, the rate of loss of bonding capacity depends on temperature.
3. Bentonites with high ion exchangeability have a higher thermal resistance than bentonites with low ion exchangeability.
4. Swelling capacity of sodium bentonites is not an essential property for use as a foundry sand binder. A high swelling capacity of sodium bentonites indicates a high thermal resistance.
5. The thermal resistance may be determined in a definite manner by differential thermal analysis. The position of the second endothermic deflection indicates the temperature of final destruction of bonding capacity and recovery properties. A gradual decrease of bonding capacity with rising temperature affects the trend of the DTA-curves by differential thermal analysis. The character of a bentonite may be determined within 2 hr. The investigations of the thermal resistance with test mixtures require tests lasting several days.
6. Green strength of bentonites in the state as delivered tells little about the life of the binder in question. Bentonites with high initial green strength, but poor heat resistance, are less economical in the long run in a system sand than bentonites with moderate bonding capacity and high thermal resistance. The results of these investigations express the practical experience with Wyoming bentonites in the foundry.
7. Natural nonswelling calcium bentonites with a high rate of ion exchange may, particularly after activation with sodium carbonate, be equivalent to natural western-type bentonites. Bentonites with high initial green strength usually have poor heat resistance.
8. Southern bentonites losing bonding capacity early by heating impart good collapsibility to a sand and easy shake-out properties.
9. Shake-out properties and collapsibility are not a function of dry strength, but of heat resistance and of loss of bonding capacity. For dry molding practice, western-type bentonite is recommended. Bentonites with quick-base exchange behavior give high dry strength.

TABLE 5 – MEDITERRANEAN BENTONITE NO. 3 PROPERTIES WITH WATER

	% natural	% Sodium treated
Hygroscopicity	7.8	7.5
Initial correct temper moisture content	2.5	2.1

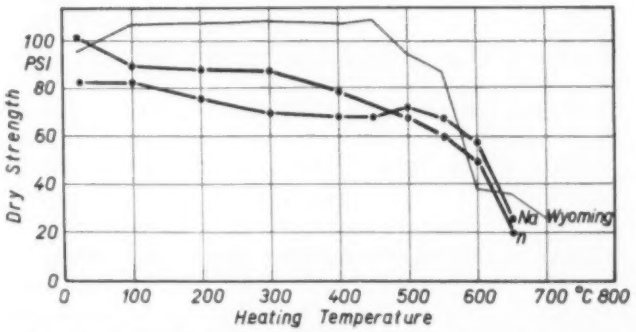

Fig. 15—Dry strength vs. heating temperature, investigated for same bentonites as with Fig. 14. 105 C, 2 hr. Wyoming bentonite shown as reference.

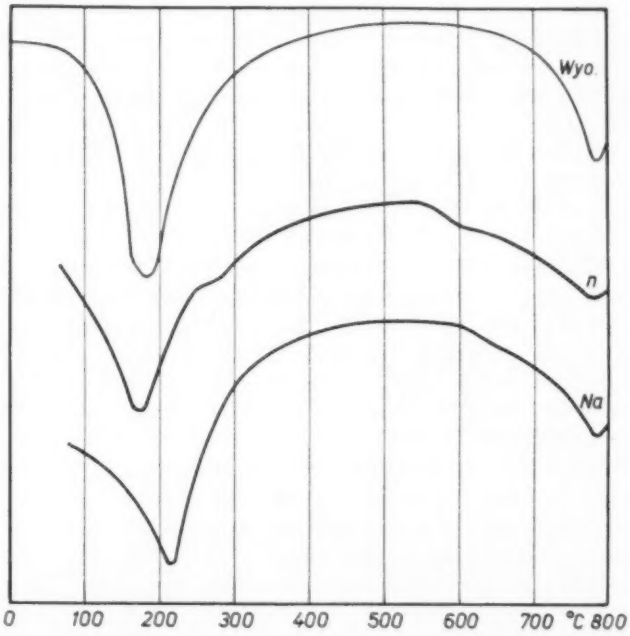

Fig. 16—Differential thermal analysis curves of Mediterranean bentonite 3: n = natural state, Na = treated with 3 per cent sodium carbonate. Curve of Wyoming bentonite shown as reference.

REFERENCES

1. H. W. Dietert and F. Valtier, "Grain Structure Control Ensures Mold Permeability Control", TRANSACTIONS AFS, *vol.* 47, pp. 175-192, 1931.
2. R. E. Grim and F. L. Cuthbert, "The Bonding Action of Clays, Part I—Clays in Green Sand". University of Illinois Bulletin, *Vol.* 42, *No.* 50, July 31, 1945.
3. W. Goetz, "A Critical Analysis of the Cylindrical Standard Test Specimen for Foundry Sands", TRANSACTIONS AFS, *vol.* 63, pp. 76-95, 1955.
4. F. Hofmann, "Beitrag zur Kenntnis und zur Untersuchung der Eigenschaften von Bentoniten", *Giesserei*, Techn.—Wiss. Beihefte 16, pp. 857-864, 1956.
5. W. Patterson and D. Boenisch, "Influence of the Clay Binder on Green Properties of Foundry Sands", Paper Nr. 16, 24th International Foundry Congress, Stockholm, 1957.
6. R. E. Grim, *Clay Mineralogy*, McGraw-Hill Book Co., New York, 1953.

GATING AND RISERING SHELL-MOLD PATTERN EQUIPMENT

By

D. C. Kidney*

Gating and risering problems confronting the pattern shop are numerous and diversified. In addition to designing the pattern equipment, it is, in most cases, the patternmaker's duty to gather pertinent information about the casting. He must co-ordinate the facts so the end result will be a pattern and gating system for production of sound castings.

This paper does not propose a cure-all for gating problems. It points out some basic principles which, combined with common sense and clear thinking, should result in improved shell-mold gating and risering practice.

Aluminum, cast iron, brass, and ductile iron shell castings are all a part of our daily production. Castings range in size from one ounce to 15 lb. Sectional areas vary from 3/32-in. to 1 in.

The design of the castings we produce, such as train control devices, decelostats for passenger trains and aircraft, brake valves, and controls used by the railroads, demands that they be sound and air tight. Effective gating and risering require changes in the original design, and sometimes takes precedence over dimensional accuracy.

Since the inception of shell molding in our plant, we have built approximately 150 sets of shell patterns. Of this group 110 remain active and have been in production during the past year.

Patterns for use in our operation are made from either aluminum or cast iron. Production requirements govern the selection of pattern material. Experimental and short-run patterns are made from aluminum, while high production runs require the use of cast iron equipment almost exclusively.

Warping of plates, rapid wear of surfaces at right angles to the parting, and reduced strength of material due to constant reheating, discourage the use of aluminum for extended runs. On the other hand, cast iron equipment is wear-resistant. Plates, when properly annealed, retain their original accuracy. Our pattern plates make a maximum size 20-in. x 30-in. shell, ranging down to a minimum size of 10-in. x 15-in.

About 80 per cent of our plates make 15-in. x 20-in. shells. This size is considered our standard, and used whenever practical.

Pouring tables filled to a depth of three or four in. with a coarse grain sand permit the bedding-in and weighting-down of shells with a minimum amount of effort. Gas and heat are allowed to escape rapidly through the open sand. Although many foundries are successfully backing up shells and using vertical gating, we have limited our operation almost exclusively to horizontal pouring.

As design and process engineers become more familiar with improved surface finish, and closer tolerances can be obtained in shell molding, inquiries about and demands for shell castings will increase. This growing demand for castings of this type makes it evident that the pattern shop and foundry must acquire the know-how to produce them.

Quality control requires rigid inspection of all shell castings. They must be sound, dimensionally accurate, and of good appearance. Proper design of patterns and gating is necessary to achieve these standards. These facts should be considered with the initial inquiries concerning shell-mold castings and equipment to produce them.

PLANNING GATING SYSTEM

In planning the gating system, careful consideration must be given to the pattern parting. A minor change in the parting line may create a better location for gates and risers. It is important to choose a parting so the removal of flashing or fins will be a simple operation.

If gates or risers must be cut, they should be placed where projections on the casting will not obstruct a straight-through cut-off operation. Ample space should be allowed between all parts mounted on the shell plate to accomplish this. This provides a better surface for applying the bonding agent, reduces surface deformities due to swells, and helps eliminate thermal cracks and break-outs in the shell.

Close cooperation of foundry personnel is required to eliminate much of the trial and error sometimes necessary to achieve satisfactory results. During the planning stage the patternmaker should consult the foundry representative. He should point out areas of the casting that may give trouble. A record of gating arrangements agreed on should be kept on file for future reference as this provides a ready source of information, and helps to avoid duplication in the future.

Estimated pattern costs that are too high are sometimes a result of uncertainty regarding the gating arrangement and the possibility of making expensive changes. High equipment costs often influence the

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designer to change to another method of manufacture. Careful planning in the initial stage will eliminate this need and keep estimates more in line with actual costs.

DESIGNING SHELL GATING

In designing successful shell gating, careful consideration must be given to pouring time. Mold cavities must be rapidly filled with molten metal. This increases the time between beginning of solidification and break-down of the shell, and tends to reduce or avoid swells in many types of castings.

Estimating the weight of casting per mold will aid in pre-determining the pouring time. Our pouring times are based on using a standard sprue and runner. Previous shell mold production was checked. Pouring times are controlled by adjusting the chokes in the runner system.

Gates and risers can be made from a number of materials. It is preferred to have the gating system made from the same material of which the mounting plate is composed. Loosening of gates and risers, spreading or opening of joints, and increased maintenance result from using material for gates and risers that differ from that of the pattern plate.

A few standard sprues made from a wear-resistant material with good heat transfer qualities, such as cast iron or hard copper, will do for the shell operation. The shell operator will change sprues from one plate to another.

SPRUE AND RUNNER BASINS

Basins used at the base of the sprue and runners for the various metals poured can be made standard and kept in stock.

If the gating system is made of component parts, a good fit at all joints is essential. Complicated gating systems require much less maintenance if cast in one piece.

Whenever possible, it is advisable to use the master, or one of the working patterns, to make a sample green-sand casting. This is a good check for planned gating and risering. Ingates, chokes, and risers should be made larger than necessary. Removal of excess material is a simple matter if an alteration in the gating system is required.

The patternmaker should have a general knowledge of gating for the various castings the foundry produces. For aluminum castings a standard 2-in. diameter sprue is used. A perforated steel strainer 2-1/2-in. in diameter, 0.012 in. thick, with perforations 0.076 in. in diameter, and having about 118 holes per sq in., is placed in the shell at the base of the sprue. A piece of sheet metal 1/2-in. larger in diameter than the sprue forms the impression for the strainer.

Metal passes through the strainer into a basin in the bottom half of the shell and back up into the cope. It passes through an area created by overlapping projections on the basin with the cope runner. The basin at the bottom of the sprue aids in smoothing the flow of metal.

USE OF GATES

Use of several gates, where possible, assists in the even distribution of metal, and permits pouring at lower temperatures. Where practical, gating through risers will assure the soundness of the casting. To insure proper feeding of a casting the risers should be designed and arranged in the gating system so they are the last part of the mold to solidify. Having them connected directly to the runner insures that they will be the last to be filled with hot metal.

Blind risers, not connected directly to the runners, and top risers should be opened to the atmosphere. Our experience indicates that opening risers results in better feeding of nonferrous castings. Flat, thin castings should be gated with as many fingers as practical and poured at reduced temperatures. High-pouring temperatures tend to cause rough surfaces directly in front of the ingates.

Objectionable flow marks that are often evident on aluminum shell castings can be minimized by making finger gates larger than necessary to run the casting. All aluminum casting gating systems should be adequately choked at the base of the sprue to reduce pressure in the runner and gates. Choking, plus the use of a perforated screen, will eliminate dross inclusions in the castings.

The zinc that is present in most brass and bronze tends to produce dross inclusions. To control these inclusions a strainer core is recommended for use at the base of the standard sprue. This chokes the sprue and reduces dross inclusions in castings.

Metal in the gating system should be free flowing. This can be greatly improved by avoiding abrupt changes in direction and use of generous radii at critical points. To help eliminate agitation of metal, free drop into ingates and mold cavities should be reduced as much as possible.

Castings that require a minimum of feeding can be fed soundly by backing up the ingates to the top of the runner. Backed-up gates and risers should be placed as close to the casting as possible as this improves feeding action. Side and top risers are used to feed heavy sections that cannot be fed by the runner. Risers not connected directly to the runner should be opened to the atmosphere. This seems to help in feeding the casting.

For light castings, an overflow opposite the ingate, and open to the atmosphere, will help avoid misruns by permitting trapped gas to escape. Gating into sections not too heavy should be done, as well as feeding from these gates. When extremely heavy sections are encountered, separate risers should be added to feed the critical areas.

PRESSURE-TYPE GATING

The direct pressure-type gating system is generally used for cast iron. This type of gate requires the area of the runner to be greater than that of the ingates. Special attention must be given heavy sections to eliminate shrinkage. Direct, or top, risers are nearly always used to avoid trouble in these areas. Side risers, although not as effective, may be used where top risers are not practical.

A basin is placed at the bottom of the sprue to aid in subduing turbulence. Flat, or knife, gates seem to give the best results in nearly all applications. Ingates are placed in the cope permitting a smoother flow of metal by eliminating cross-over.

Free drop into mold cavities should be eliminated as much as possible by causing metal to flow over the contour and gradually fill deeper parts of the mold. It must be kept in mind that ingates should be large enough to avoid spurting action, and small enough to choke the runner. In by-passing that last ingate with the runner, a good trap is formed for any inclusions entering the shell with the initial surge of metal.

In addition to the conventional pressure-type gate, the Connor block can be used in many applications. Although its use is limited, there are many possibilities for it. It is particularly adaptable to flat-back castings of small size. The block which is either square or rectangular is placed entirely in the cope and overlaps the edge of the mold cavity 1/16-in. Increasing the overlap to more than 1/16-in. frequently results in pin holes in that area.

The usual method is to use the standard sprue and runner with ingates entering the block at right angles to the runner. The size of the block should be approximately one-third the mass of the casting. It is good practice to make the block larger than necessary in order to assure enough pressure to fill the mold cavity.

In some instances, the runner may be used as a Connor block. This is done by extending projections the same height as the runner at right angles to the initial flow of metal, and overlapping each pattern the required amount. Castings are easily removed from this gate leaving a small indentation at the location of the overlap. Variations of this type gate are many and limited only to casting design.

Direct- and Indirect-Pressure Type

Both direct and indirect pressure type gates are used for ductile iron. We use our standard 2-in. sprue. A basin 2-in. in diameter, and 1-1/4-in. deep is placed at the bottom of it. The runner and ingates are placed in the cope to aid in trapping slag and reducing turbulence.

The portion of the runner attached to the sprue is the choke area. Immediately after the choke area is a slag trap. The slag trap is usually about three times as high as the runner, and about twice as long as the choked area.

Following the trap, the runner is choked once more as added protection against inclusions. In the direct-pressure method of gating, ingates enter the mold cavity directly from the runner. In the indirect-pressure type of gate an ingate from the runner enters a riser which feeds the casting.

The height of runners will vary in ductile iron gating depending on the size of the ingates. Where they are attached to the casting, ingates and risers should be kept open. Necking down these areas invariably results in shrinkage. Side risering is the most effective method of feeding heavy-sectioned ductile iron castings, and usually simplifies the cut-off operation.

The majority of ductile iron gates and risers must be removed by chipping or cutting off. These are expensive operations in the foundry cleaning rooms, so careful consideration should be given the selection of the area to which gates and risers will be attached.

PLACING GATES AND RISERS

Placing of gates and risers where a projection on the casting might obstruct a straight cut-off operation, should be avoided. A simple, straight-through operation should be provided. This will tend to avoid scrap by helping to eliminate the possibility of cutting into the casting itself.

The Connor-block riser may be used effectively for light, flat-back ductile iron work. The advantage of this type gate or riser is the reduction of cleaning costs due to the easy removal from castings.

SUMMARY

When designing or building a gating system for shell patterns, it would be well to keep these facts in mind:

1. Whenever possible, work closely with the foundry in planning the equipment.
2. Make a trial run in green sand. This will allow corrective action to be taken before an expensive gating arrangement is assembled.
3. Standardize as many items as possible such as sprues, basins, runners, and strainer gates. Standardization here can result in work simplification and substantial savings in pattern equipment.
4. To smooth the flow of metal, avoid crossing over ingates with the runner.
5. Place a basin at the bottom of the sprue. This reduces turbulence and aspiratory action.
6. Extend runners past ingates to form a bypass to trap inclusions.
7. Round corners on gates and runners with substantial radii for additional mold strength.
8. Avoid excessive free drop of metal into gates and mold cavities.
9. Arrange the gating system to permit short pouring times.
10. Do not crowd patterns and gates. Use material for gating that is compatable with the mounting plate.

With the use of a few basic principles, cooperative action with the foundry, and some careful thought, much trial and error can be eliminated. Many gating problems can be solved in the pattern shop before production begins.

SODIUM SILICATES FOR THE CO_2 PROCESS

By

E. A. Lange* and R. E. Morey*

ABSTRACT

The chemistry of the CO_2-Sodium Silicate Process for bonding foundry sand was investigated with particular attention given to the composition of the sodium silicate, CO_2 utilization, and drying procedures.

The rate at which strength develops with CO_2 is dependent on the SiO_2/Na_2O ratio of the sodium silicate. The maximum strength developed with CO_2, is dependent on the SiO_2/H_2O ratio of the sodium silicate and can be as high as 500 psi. Drying ungassed sand mixtures will produce strengths in excess of 2000 psi. But the dry strength of sand which has been gassed with CO_2 is dependent upon the composition of the sodium silicate and the gassing time; dry strength can be less than the gassed strength.

The amount of CO_2 necessary to develop maximum gassed strength is that required to increase the SiO_2/Na_2O ratio of the sodium silicate to 4. However, at low CO_2 flow rates the sodium silicate will absorb an amount of CO_2 equivalent to 1.0 to 1.5 times the amount of Na_2O present. The efficiency of the CO_2 gassing process can be greatly increased by diluting the CO_2 with air.

INTRODUCTION

Sand mixed with sodium silicate solutions can be hardened by exposure to CO_2 in a matter of seconds. This short time required to develop a level of strength sufficient for molds and cores is a most important advantage over conventional methods which require hours of baking time. For a great many applications of this CO_2 process a rammed core or mold can be prepared in a matter of seconds rather than minutes or hours and without a baking period. Many techniques using commercial formulations have been described [1,2,3], but the inherent flexibility of the process can only be utilized by foundrymen having a knowledge of the importance of the parameters involved.

It was the purpose of this investigation to determine the strength characteristics of the sand mixture that are related to the composition of the sodium silicate solution and to evaluate such factors as mixing order, CO_2 flow rate, and drying techniques.

CHEMISTRY OF THE CO_2 PROCESS

The most important material involved in the CO_2 process is the bonding agent, so it is appropriate to briefly discuss the composition and physical properties of commercial sodium silicate solutions using the method of manufacture as a starting point[4].

The most common method for manufacturing soluble sodium silicates is to heat mixtures of sodium carbonate and silica sand in open hearth type furnaces. The sodium carbonate begins to decompose at 730 F and CO_2 gas is driven off. Fusion of the resulting soda with the silica sand occurs about 1380 F. But the temperature is slowly raised to 2550 F to complete the reaction in a short period of time and produce a fluid molten glass. The molten glass is then either quenched directly into water and slowly dissolved at atmospheric pressure, or chilled to a solid and subsequently dissolved in water under 100 psi steam pressure. Both dissolving methods require close control.

Sodium silicate solutions having viscosities comparable to the viscosities of light to heavy syrups and also some solid hydrates, are produced from glasses with SiO_2/Na_2O ratios from 1.6 to 3.75. Solid hydrates of low ratio sodium silicates dissolve quite readily, but solid hydrates of high ratio silicates and anhydrous glasses dissolve very slowly at atmospheric pressure.

The relationships between the density and the composition of sodium silicate solutions have been extensively investigated. Knowing any two of the four factors (per cent sodium oxide, per cent silica, density, or SiO_2/Na_2O ratio) the other factors can readily be determined by means of the graph in Fig. 1. The relationships in Fig. 1 are valid only for 68 F as the density is affected by temperature. Density determinations with hydrometers require special care to avoid having any of the heavy liquid on the stem of the hydrometer above the measuring surface.

The physical chemistry of sodium silicate solutions is related to the amount of material that dissociates as ions and the amount that exists as a colloid. Vapor pressure is a property that is very sensitive to the degree of subdivision of solutes, and comparisons of the vapor pressures of sodium silicate solutions can be used to indicate the colloidal nature of the various sodium silicates.

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The curves in Fig. 2 show that high ratio sodium silicate solutions contain more colloidal material than low ratio sodium silicate solutions because the vapor pressure of the former solutions is less affected by increasing concentration than the latter solutions. The cloudy appearance of sodium silicate solutions is also indicative of the presence of colloidal particles. Much of the sodium silicate in commercial solutions is truly in solution, however, and chemical reactions with acids are basically ionic in nature and very rapid. The overall reaction rate between CO_2 gas and viscous sodium silicate solutions may be slow, however, due to the great increase in viscosity which decreases the rate of diffusion.

The curves in Fig. 3 illustrate the relationship between viscosity and concentration of sodium silicate solutions having various SiO_2/Na_2O ratios. It can readily be seen that the viscosities of high ratio sodium silicate solutions rise much faster with increasing concentration than do the viscosities of low ratio sodium silicate solutions. The moisture content of the sand, addition of hygroscopic materials, and loss of small amounts of water during mixing would thus be more critical when using high-ratio sodium silicates than when using low-ratio sodium silicates. The curves terminate with a SiO_2/Na_2O ratio of 4.0 as solutions having SiO_2/Na_2O ratios greater than 4.0 are either unstable liquids or gels at all concentrations.

The addition of Na_2CO_3 to sodium silicate solutions in the proportion which would be obtained from absorption and reaction with CO_2 would not in itself cause a notable increase in viscosity.

The addition of acids, such as carbonic acid from the solution of CO_2 gas in effect increases the SiO_2/Na_2O ratio by immobilizing some of the Na_2O as Na_2CO_3 which causes a drastic change in viscosity. The change in viscosity is attributed to aggregation of the silica particles into larger and larger particles which retain quantities of sodium ions and tend to remain in solution. Eventually, the aggregates gel and the gels by themselves tend to give off water by a process called syneresis which can occur over a period of hours or days depending on the conditions.

The quantity of CO_2 necessary to change the viscosity of a sodium silicate solution which is initially

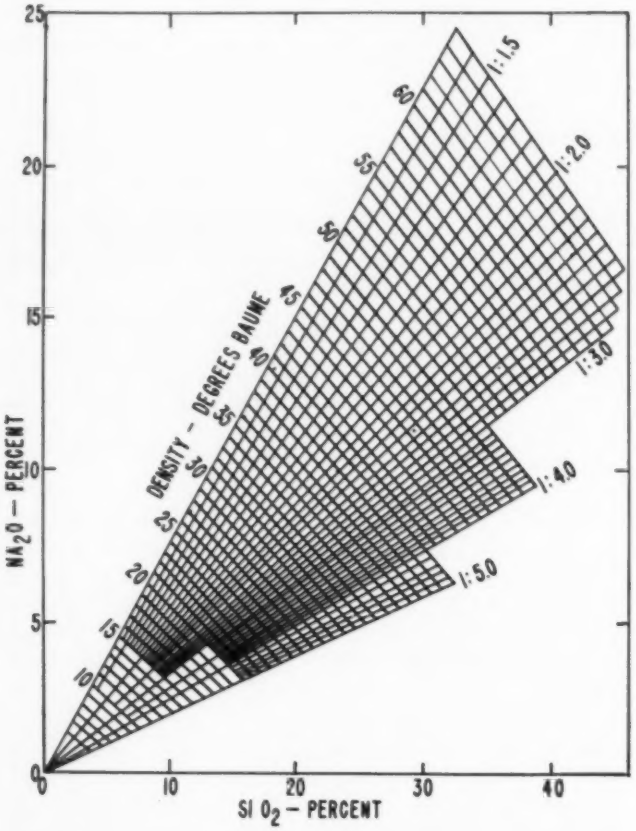

Fig. 1—Relationship between density (°Be') and composition of sodium silicate solutions at 68 F.

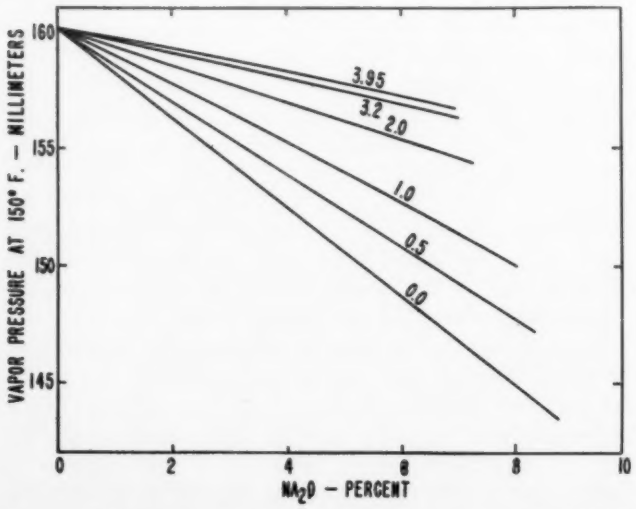

Fig. 2—Illustrating the colloidal nature of sodium silicate solutions by reduction in vapor pressure.

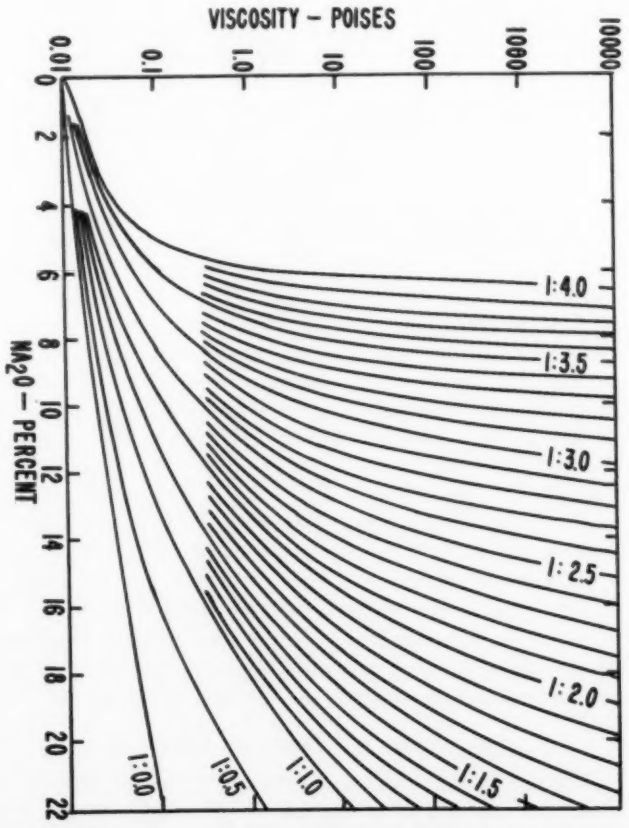

Fig. 3—Illustrating the effect of concentration on viscosity of sodium silicate solutions.

less than 100 poises to a viscosity of 10,000 poises, equivalent to the viscosity of a stiff tar, depends upon the composition of the sodium silicate solution. Solutions of low-ratio sodium silicates require more CO_2 than solutions of high-ratio silicates, both having the same initial viscosity. These composition and viscosity changes can best be visualized with the aid of a triangular plot of the three constituents of the solutions, Fig. 4, giving the nature of the solutions in the various regions.

The composition change due to a reaction with an acid will follow on a line drawn from the Na_2O corner through the initial composition point. The addition or removal of water to a solution will cause the composition to change along a line drawn from the H_2O corner through the initial composition point. It can be seen that very high viscosity solutions can be obtained by either a reaction with an acid or by removal of a small amount of water, but the glasses can only be obtained by appreciable reduction in water content.

The addition of sugars to sodium silicate solutions used for bonding core sand is common practice. The sugars act as hygroscopic agents and reportedly aid in the breaking of the silicate bond after exposure to molten metal temperatures. Common sugar (cane or beet) is sucrose having the formula C_{12} $H_{22}O_{11}$.

Invert sugar is a 50-50 mixture of dextrose and levulose both having the formula $C_6H_{12}O_6$. Invert sugar is generally made by hydrolyzing sucrose with an acid which splits the sucrose molecule and adds one molecule of water. Three types of liquid invert sugars are marketed which have different proportions of invert sugar.

The range of compositions for each type of invert sugar and sucrose sugar are given in Table 1. Several grades depending on color and purity are marketed. Liquid sugars having a low pH value or containing an excessive quantity of salts tend to react with sodium silicate solutions. This drastically limits the storage life of a proposed mixture of sugar and silicate. However, mixtures which are used immediately can probably utilize the lower grade, less costly sugars.

Liquid sugars of the medium invert type contain the highest quantity of solid material without crystalizing at ambient temperatures, and are hygroscopic. These two properties make medium invert sugars the most desirable type for use as addition agents to sodium silicate solutions. Sugars do not directly enter into the aggregation reaction of sodium silicates and do not influence the rate of reactions[1]. The effect of their presence, in so far as the CO_2 reaction is concerned, is purely one of dilution of the sodium silicate without the deleterious effects produced by an equivalent amount of water.

MATERIALS AND APPARATUS

The materials used for this investigation were: commercial grades of sodium silicate solutions, chemical compositions listed in Table 2; a silica sand, screen distribution listed in Table 3; and a medium invert liquid sugar containing 76 per cent solids with a density of 11.6 lb per gallon. A schematic diagram of the CO_2 gassing apparatus is shown in Fig. 5. The CO_2 flow rates were measured by means of calibrated rotometers.

A high flow rate, 0.3 cfm, was used for the experiments conducted to determine the overall reaction rate of the various sodium silicate solutions. A low flow rate, 114 cc per min., was used for the experiments conducted to determine the amount of CO_2 utilized when the reaction rate was not a controlling factor. For a 155 gm sand sample the high flow rate was equivalent to 11 wt per cent per/min and the

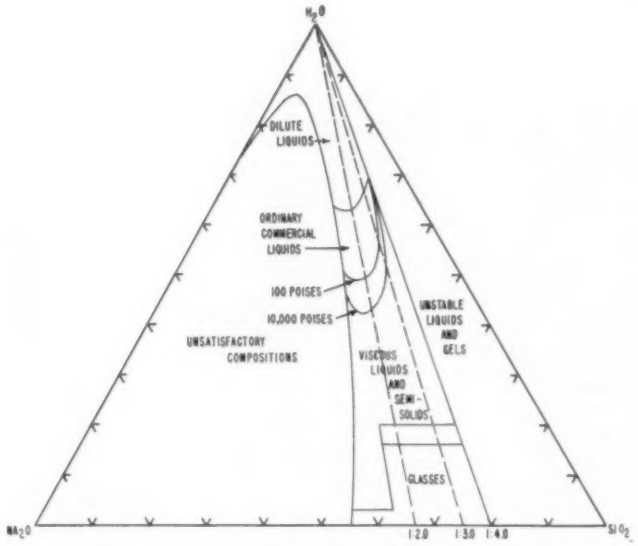

Fig. 4—Physical characteristics of sodium silicate solutions.

TABLE 1 – COMPOSITION OF LIQUID SUGARS

Type of Liquid Sugar	Total Solids Content, %	Invert Sugars, % of Solids
Sucrose	66–67	0.1– 0.3
Low	66–69	2 –20
Medium	74–79	20 –75
High (Total)	70–77	75 –99

TABLE 2 – COMPOSITION OF SODIUM SILICATES

Type*	Na_2O, Wt. Ratio	SiO_2, Wt. Ratio	H_2O Wt. Ratio	SiO_2/Na_2O Wt. Ratio	SiO_2/H_2O Wt. Ratio
A	14.4	29.1	56.5	2.00	0.515
B	13.9	33.1	53.0	2.38	0.625
BC	12.4	32.3	55.3	2.60	0.584
C	10.9	31.6	57.5	2.90	0.550
D	9.03	28.9	62.1	3.20	0.465

*All are commercial solutions except BC which was a 50-50 mixture of types B and C.

TABLE 3 – SIEVE ANALYSIS OF WASHED SILICA SAND

Sieve	Percent
through 30 on 40	0.1
through 40 on 50	2.2
through 50 on 70	12.9
through 70 on 100	54.2
through 100 on 140	23.1
through 140 on 200	5.5
through 200 on 270	1.3
through 270 on Pan	0.7

Median Size	– 182	microns
Sorting Coefficient	– 1.176	
Skewness Coefficient	– 0.927	
Specific Surface	– 208	cm^2/g
Grain Fineness Number	– 80.8	
Moisture	– 0.1%	

low flow rate was equivalent to 0.143 wt per cent per/min. A spacer block was used in the ramming tube for the low CO_2 flow rate experiments to decrease the volume of air in the system. A down stream rotometer was not used for the high flow rate experiments as the amount of CO_2 absorbed was only a small fraction of the total flow.

MIXING ORDER

The sodium silicate solutions suitable for sand binders are quite sticky, and proper distribution is necessary to develop the maximum number of bonds between the sand particles. However, if the sand is very dry or drying occurs during the mixing cycle the silicate will become very viscous. When this occurs the silicate does not wet the sand grains and the sand will feel dry.

Four different mixing sequences were initially tried to determine the proper mixing order of ingredients. The sodium silicate having a mid-range ratio, SiO_2/Na_2O of 2.38, was used and compressive strengths of the various mixes were determined for gassing times extended to 200 seconds. The mixing procedures and resulting gassed strengths are given in Fig. 6. The data in Fig. 6 show that a sand mixture prepared by adding the silicate, syrup, and water to the sand and then mixing for 3 minutes developed a higher gassed strength than sand mixtures prepared by mixing the ingredients separately with the sand or premixing the liquid ingredients and then adding the composite liquid to the sand. All subsequent mixtures were prepared by the former method.

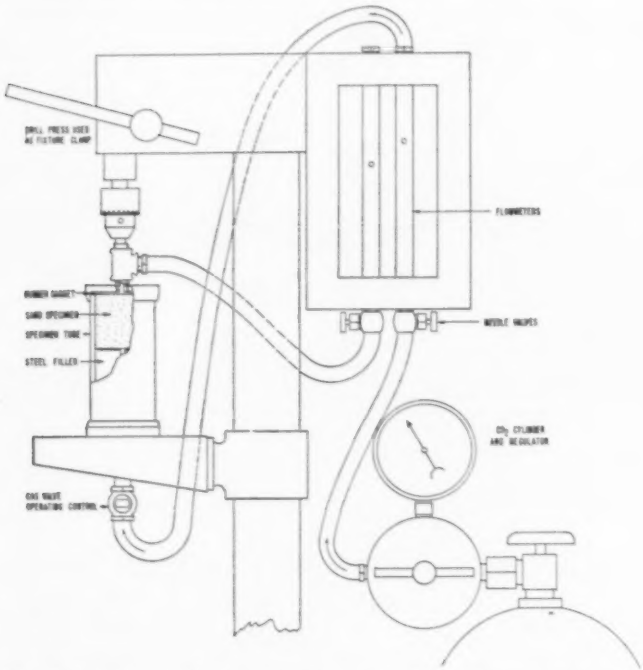

Fig. 5—Arrangement for measuring gas flow into and out of sand specimen.

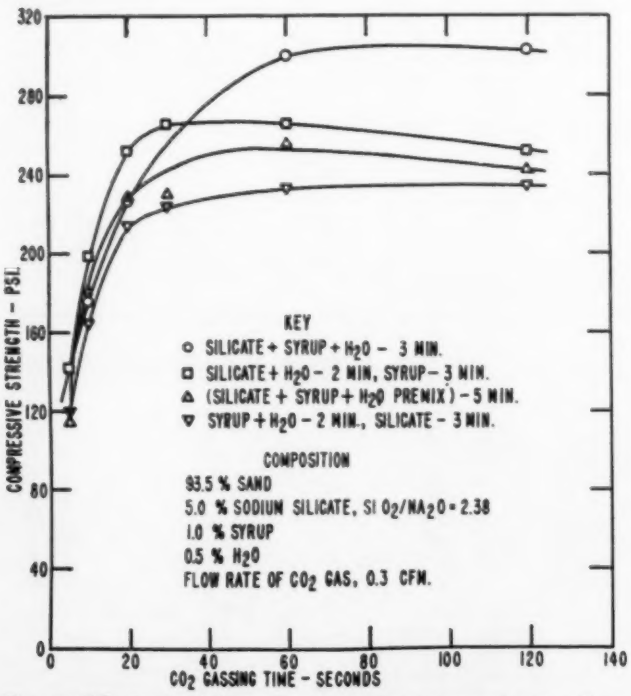
COMPRESSIVE STRENGTH - PSI.
CO_2 GASSING TIME - SECONDS
KEY
○ SILICATE + SYRUP + H_2O - 3 MIN.
□ SILICATE + H_2O - 2 MIN, SYRUP - 3 MIN.
△ (SILICATE + SYRUP + H_2O PREMIX) - 5 MIN.
▽ SYRUP + H_2O - 2 MIN., SILICATE - 3 MIN.
COMPOSITION
93.5 % SAND
5.0 % SODIUM SILICATE, SiO_2/Na_2O = 2.38
1.0 % SYRUP
0.5 % H_2O
FLOW RATE OF CO_2 GAS, 0.3 CFM.

Fig. 6—Effect of mixing order on gassed strength of sodium silicate bonded sand.

CO_2 GASSED STRENGTH

It was pointed out in the previous section that high viscosity liquids or gels can be obtained by gassing with CO_2, by drying, or by a combination of both gassing and drying. The sand bonding characteristics derived by these two processes were investigated for commercial sodium silicate solutions having SiO_2/Na_2O ratios equal to 2.00, 2.38, 2.60, 2.90 and 3.20. The sand mixtures contained 7 per cent sodium silicate solution, 1 per cent liquid sugar and no added water. The seemingly large addition of sodium silicate, 7 per cent, was necessary to obtain reproducible results with the silicates having the higher ratios without adding water. So 7 per cent was made the stand-

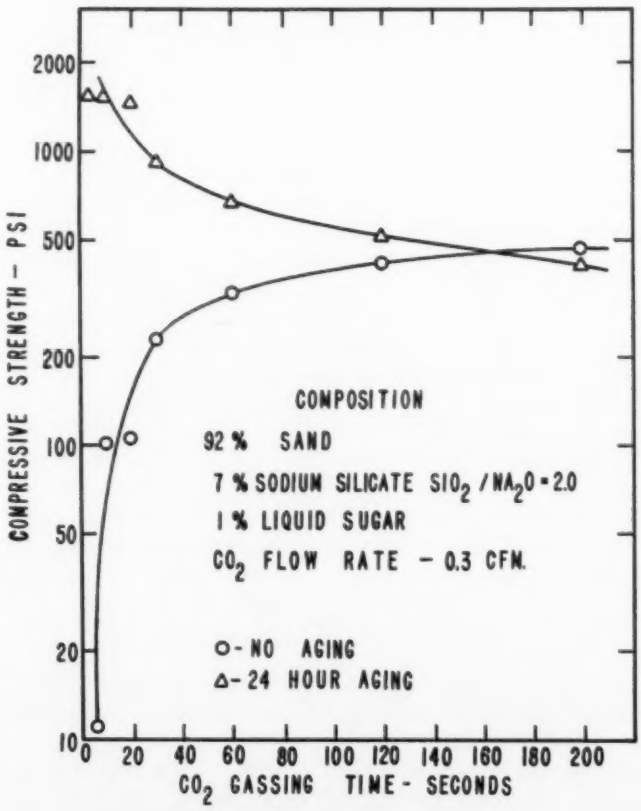
COMPRESSIVE STRENGTH - PSI
CO_2 GASSING TIME - SECONDS
COMPOSITION
92 % SAND
7 % SODIUM SILICATE SiO_2/NA_2O = 2.0
1 % LIQUID SUGAR
CO_2 FLOW RATE - 0.3 CFM.
○ - NO AGING
△ - 24 HOUR AGING

Fig. 7—Illustrating bonding characteristics of sodium silicate with $SiO_2/Na_2O = 2.00$.

ard addition for these tests. Standard 2 x 2-in. test specimens were rammed and gassed at a CO_2 flow rate of 0.3 cfm.

Specimens for gassed strength were tested immediately. Specimens for the 24 hr strengths were dried at ambient conditions of temperature and humidity. The compressive strengths obtained are presented graphically in Fig. 7-11.

The first apparent observation from an examination of the compressive strength vs gassing time curves in Fig. 7-11, is that all of the gassed strength curves and all of the 24 hr strength curves have the same characteristic shapes. Compressive strength developed very rapidly in the first 10-60 seconds of the gassing period and then remained at the same relative level. When the samples were aged for 24 hr after gassing, the strength-gassing time relationship was just the reverse. Very high strength levels were obtained only when samples were gassed for periods less than 10-60 seconds, depending on the silicate.

At longer gassing times the 24 hr strength decreased and became appreciably less than the gassed strength. The rate at which the strength levels change with gassing time is important and varies with the SiO_2/Na_2O ratio of the sodium silicate solution. High ratio silicates developed gas strength at faster rates than low-ratio silicates, but 24 hr strengths of the high-ratio silicates were very low, 100 psi, when initially gassed for periods longer than 20 seconds.

The variation in the basic strength characteristics of the different sodium silicates give flexibility to the CO_2 process and custom binders can be compounded for each application. If a core or mold is to be used immediately and a short gassing period is desired, the high ratio silicates (2.60 to 2.90)are most appropriate. But if strengths greater than 1000 psi or good shelf-life are desired the low-ratio silicates (2.0-2.4) are most appropriate.

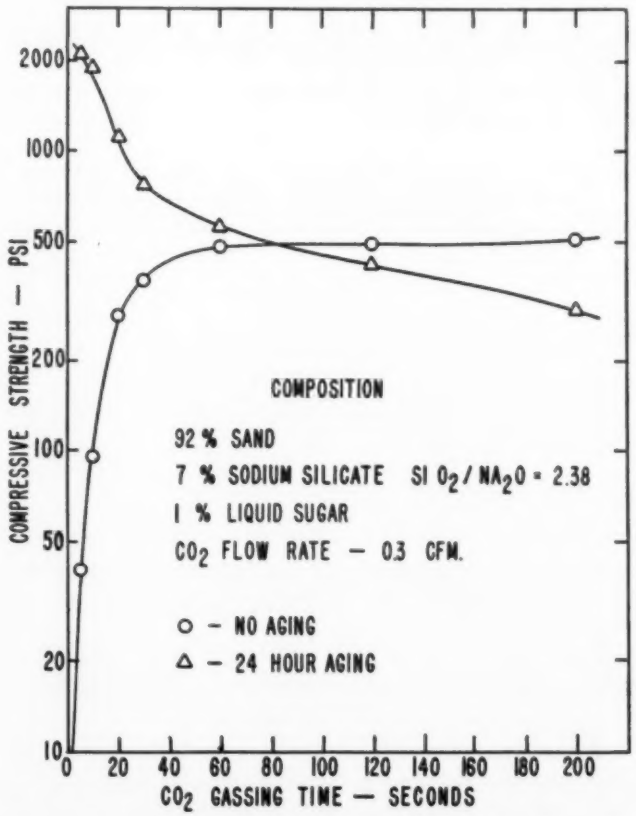

Fig. 8—Illustrating the bonding characteristics of sodium silicate with $SiO_2/Na_2O = 2.38$.

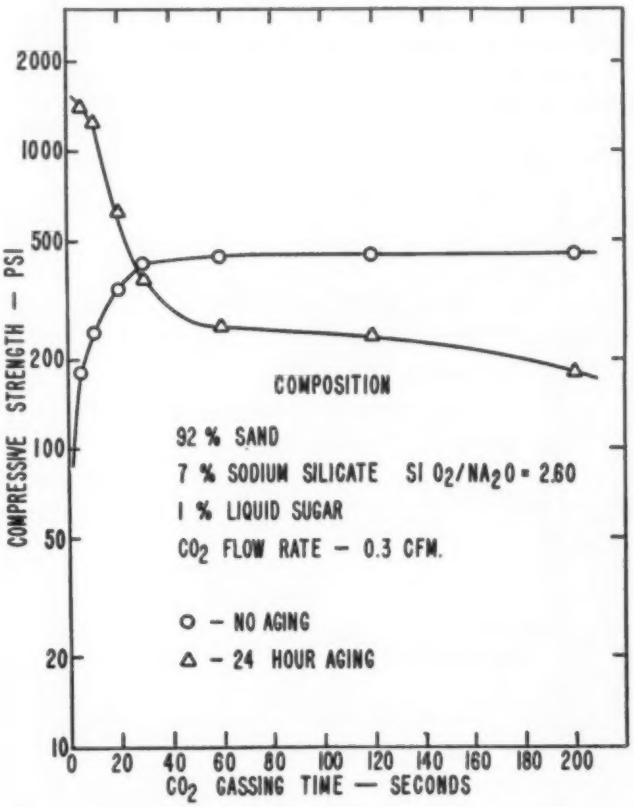

Fig. 9—Illustrating the bonding characteristics of sodium silicate with $SiO_2/Na_2O = 2.60$.

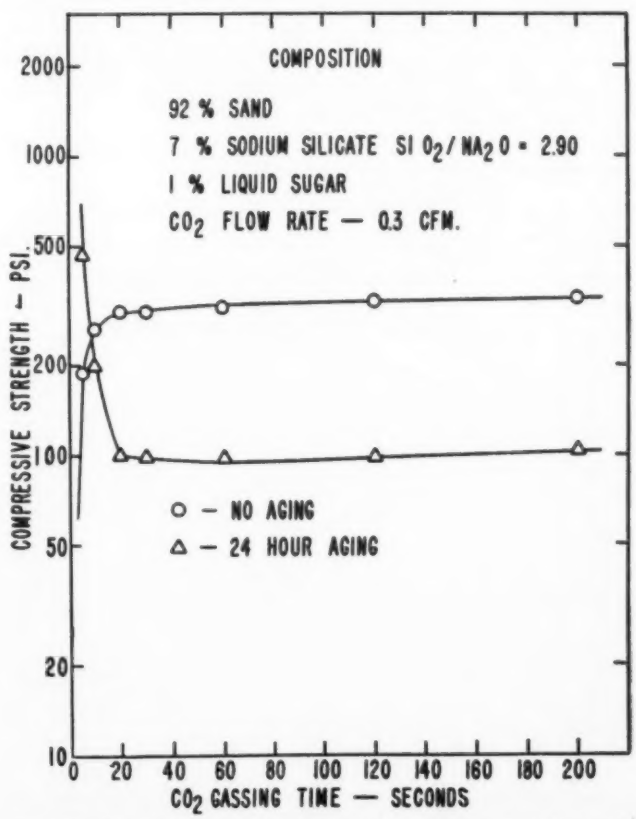

Fig. 10—Illustrating the bonding characteristics of sodium silicate with $SiO_2/Na_2O = 2.90$.

Sand mixtures bonded with low-ratio sodium silicate solutions require a longer gassing time to attain a usable compressive strength than sands bonded with high-ratio silicates because they normally have higher Na_2O contents and a greater amount of Na_2O must be reacted to attain a high level of viscosity. In Fig. 12 a comparison is made between the actual gassing times to reach 200 psi compressive strengths for sands bonded with the five commercial sodium silicate solutions (see Fig. 7-11) and the calculated amount of Na_2O reacted, or amount of CO_2 required, for attaining a viscosity of 10,000 poises (see Fig. 4). Pertinent data for the calculated values in Fig. 12 are given in Table 4.

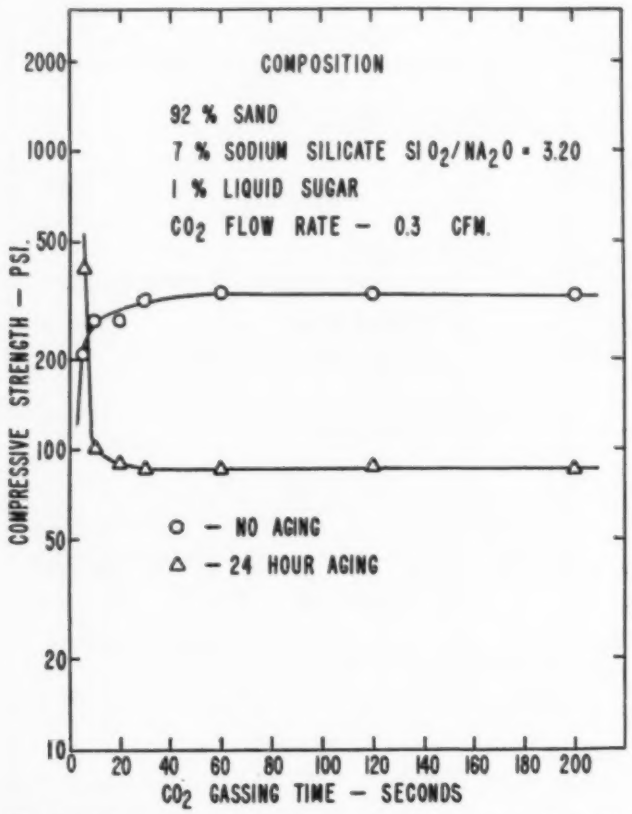
COMPOSITION
92 % SAND
7 % SODIUM SILICATE SiO_2/Na_2O = 3.20
1 % LIQUID SUGAR
CO_2 FLOW RATE – 0.3 CFM.
○ – NO AGING
△ – 24 HOUR AGING
COMPRESSIVE STRENGTH – PSI.
CO_2 GASSING TIME – SECONDS

Fig. 11–Illustrating the bonding characteristics of sodium silicate with $SiO_2/Na_2O = 3.20$.

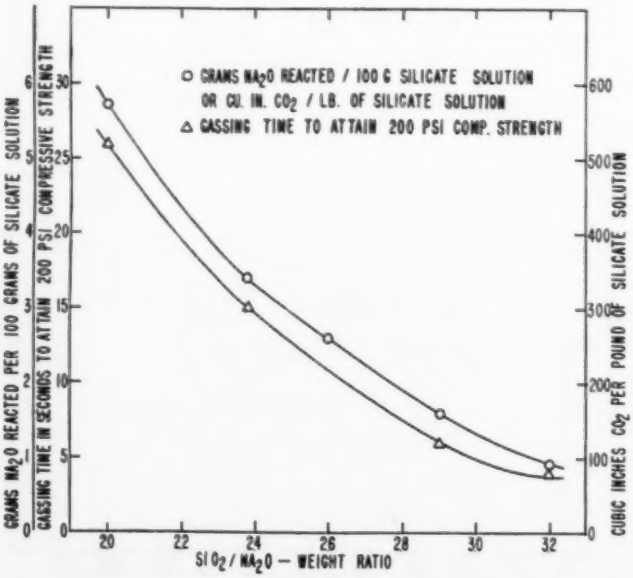
○ GRAMS Na_2O REACTED / 100 G SILICATE SOLUTION OR CU. IN. CO_2 / LB. OF SILICATE SOLUTION
△ GASSING TIME TO ATTAIN 200 PSI COMP. STRENGTH
GRAMS Na_2O REACTED PER 100 GRAMS OF SILICATE SOLUTION
GASSING TIME IN SECONDS TO ATTAIN 200 PSI COMPRESSIVE STRENGTH
CUBIC INCHES CO_2 PER POUND OF SILICATE SOLUTION
SiO_2/Na_2O – WEIGHT RATIO

Fig. 12–Comparison of CO_2 gassing time to attain 200 psi compressive strength, calculated Na_2O reacted and CO_2 required to attain 10,000 poise viscosity with commercial sodium silicate solutions.

The actual amount of CO_2 reacted with a high flow rate of CO_2 was determined for a sand mixture containing 5 per cent of type B silicate and 1 per cent of liquid sugar by weighing a standard compressive strength specimen before and after gassing. The amount of water removed by the excess CO_2 flow through the sand was obtained by drying the specimens at 110 C (230 F) and determining the difference in weight loss for the various gassing periods. The data obtained are presented in Table 5. The calculated compositions of the sodium silicate after the various gassing periods indicate that a viscosity greater than 10,000 poises was attained and the SiO_2/Na_2O ratio approached 4.

A volumetric method was also used to determine the amount of CO_2 reacted, but the flow rate of CO_2 was low enough to control the rate of absorption. A series of experiments was performed with sand mix-

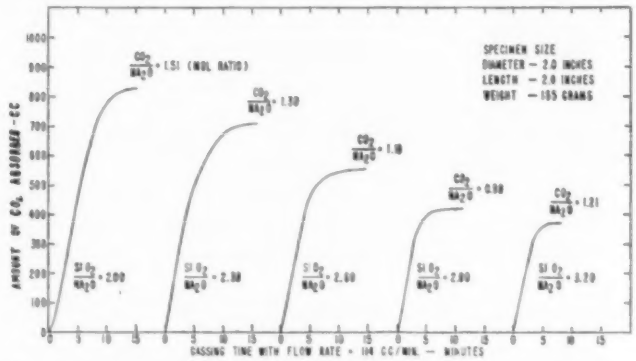
SPECIMEN SIZE
DIAMETER – 2.0 INCHES
LENGTH – 2.0 INCHES
WEIGHT – 155 GRAMS
AMOUNT OF CO_2 ABSORBED – CC
GASSING TIME WITH FLOW RATE = 114 CC/MIN. – MINUTES

Fig. 13–Comparing amount of CO_2 absorbed by various sodium silicates at low CO_2 flow rate.
Sand mixture: 92 per cent silica sand, 7 per cent sodium silicate, 1 per cent liquid sugar.

TABLE 4 – CALCULATED CO_2 REQUIRED TO OBTAIN A VISCOSITY OF 10,000 POISES WITH COMMERCIAL SODIUM SILICATE SOLUTIONS

Type	SiO_2/Na_2O Wt. Ratio	Na_2O Content, % Initial	Na_2O Content, % At 10,000 Poises*	Gms. Na_2O** Reacted per 100 gms. Solution
A	2.00	14.4	9.2	5.7
B	2.38	13.9	10.9	3.4
B-C	2.60	12.4	10.1	2.6
C	2.90	10.9	9.6	1.6
D	3.20	9.0	8.2	0.93

*Data from Fig. 4.
**Gms. Na_2O/100 gms Solution = 100 in.^{3} CO_2/lb Solution.

TABLE 5 – COMPOSITION OF SODIUM SILICATE AFTER GASSING WITH CO_2*

CO_2 Gassing Time, Sec.	Increase in Wt.** After Gassing, gms.	Wt. Loss at 110C, gms.	Wt. CO_2 Pick up, gms.	Composition of Sodium Silicate Na_2O	SiO_2	H_2O
0	0.0	4.17	0.0	13.9	33.1	53.0
30	0.17	4.12	0.22	10.4	34.7	54.9
60	0.20	4.09	0.28	9.4	35.2	55.4
120	0.15	4.00	0.32	8.8	36.0	52.2
200	0.0	3.89	0.28	9.8	36.6	53.6

* Flow rate = 0.3 cfm
** Total initial wt. = 155 gms.
Composition: 5% Type B Sodium Silicate
1% Liquid Sugar

tures containing the five types of sodium silicates using a CO_2 flow rate of 114 cc per min. With this low flow rate the amount of CO_2 absorbed could be accurately determined with the experimental apparatus shown in Fig. 5. Pertinent data obtained are shown graphically in Fig. 13.

The amount of CO_2 absorbed when the flow rate limited the rate of absorption was three to five times that necessary to develop maximum gassed strength at higher flow rates. The decreased amount of CO_2 in all but one case, type C silicate, was more than enough to completely react with all of the Na_2O present. This is not likely to be the case, as SiO_2 has a great affinity for Na_2O and the excess CO_2 is probably held in solution. The data do indicate, however, that gassing at low flow rates or for long periods of time, excessive amounts of CO_2 will be required to develop maximum strength throughout the sand mass. Compressive strength curves comparable to those shown in Fig. 7-11 were also obtained at the low CO_2 flow rate, and maximum strengths were attained at approximately 5 minutes of gassing time for all of the sand mixtures.

The maximum strength of a sand mixture obtained by the CO_2 reaction is dependent on such factors as distribution of the sodium silicate, percentage of sodium silicate, surface area of the sand, density of sand mixture, and loss of moisture during mixing as well as the composition of the sodium silicate. The variables related to the type of sand used and the ramming procedures, can be more advantageously determined for individual foundry practices, but the strength factors related to the composition of the sodium silicate will be common to all practices.

Strength of the bonding material itself is obtained by aggregation of the silica in the binder. So the amount of water held by the aggregates is important, and a correlation between compressive strength obtained by the CO_2 reaction and the SiO_2/H_2O ratio of the binder would be expected. The relationship between compressive strength and water content of sands bonded with 7 per cent of the various sodium silicates is shown by the upper curve in Fig. 14. A closer relationship, lower curve in Fig. 14, was obtained when various amounts of water were added to the same sodium silicate.

Except for the case where the sodium silicate does not properly wet the sand because of initial high viscosity or high viscosity resulting from dehydration during mixing, added water will decrease the strength obtained by gassing with CO_2. Poor wetting or distribution is most apt to occur with high ratio silicates. So from a basic viewpoint, higher gassed strengths

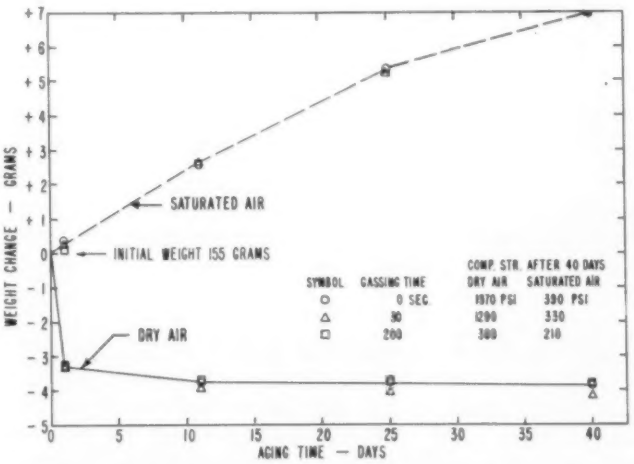

Fig. 15—Weight change of sodium silicate bonded sand aged in dry air and saturated air for extended time period. Sand contained 7 per cent sodium silicate with $SiO_2/Na_2O = 2.38$ and 1 per cent liquid syrup.

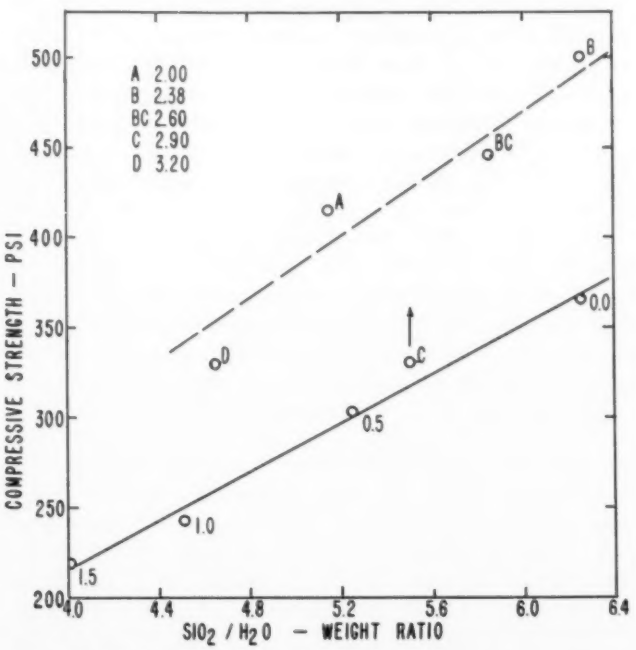

Fig. 14—Illustrating the relationship between compressive strength after two minutes gassing with CO_2 and the SiO_2/H_2O ratio of the sodium silicate. Upper curve for sand with 7 per cent commercial sodium silicates. Lower curve for sand with 5 per cent of B silicate plus indicated percentages of water.

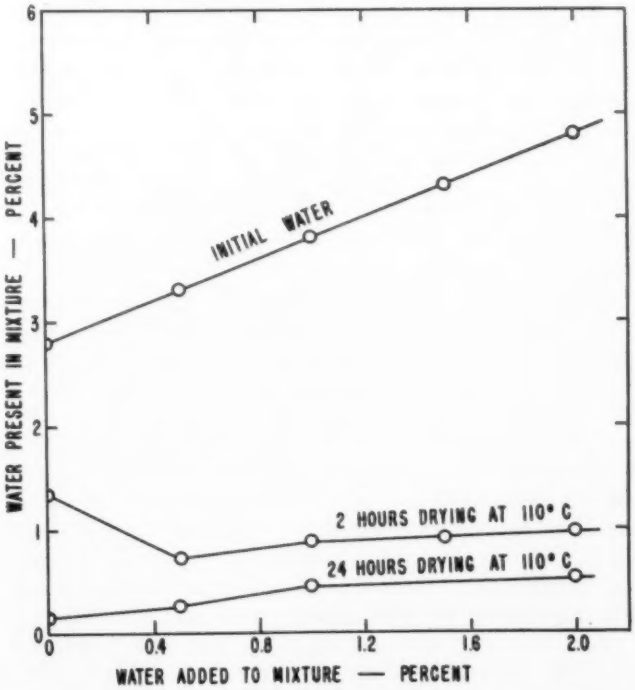
INITIAL WATER
2 HOURS DRYING AT 110° C
24 HOURS DRYING AT 110° C
WATER PRESENT IN MIXTURE — PERCENT
WATER ADDED TO MIXTURE — PERCENT

Fig. 16—Water content of ungassed sodium silicate sand mixtures after drying at 110 C (230 F). Mixture contained 5 per cent sodium silicate ($SiO_2/Na_2O = 2.38$) and 1 per cent liquid sugar (79 per cent solids).

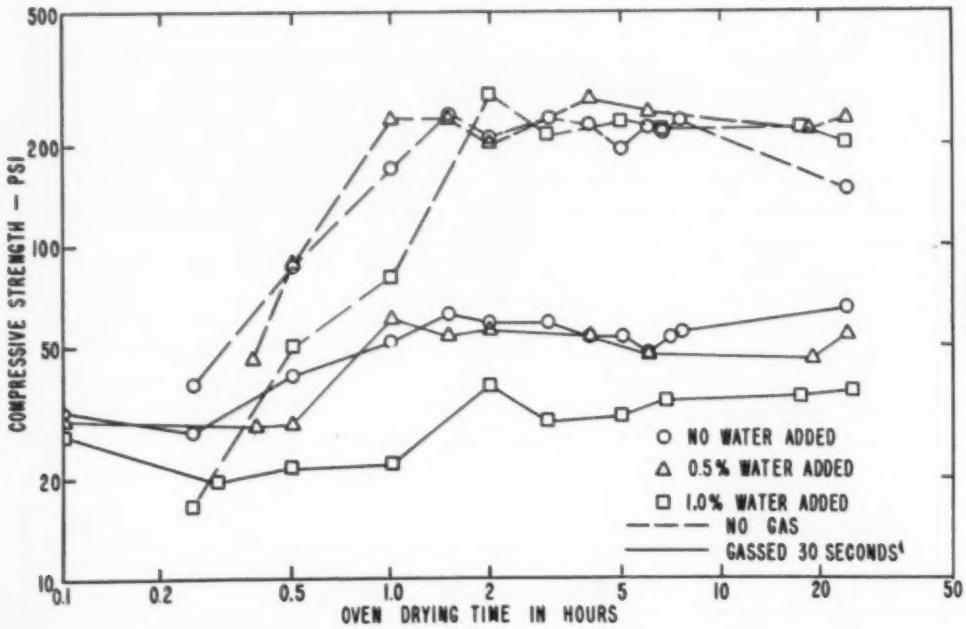

Fig. 17—Illustrating compressive strength of sodium silicate bonded sand after drying at 110 C (230 F).

can be obtained with the low ratio silicates (Na_2O/SiO_2, to 2.0-2.4) than with the high ratio silicates (Na_2O/SiO_2, to 2.6 to 3.2).

DRY STRENGTH

The compressive strength of sodium silicate bonded sand that was allowed to air dry after gassing with CO_2 was found to be dependent on the type of base silicate used and the gassing time, Fig. 7-11. When sand samples were dried for periods greater than 24 hr the compressive strengths were of the same order of magnitude as the 24 hr samples, but the values were inconsistent. It was suspected that the moisture content of the air was affecting the strength, so an experiment was performed to determine the effect that an extreme range of moisture content of the air would have on the weight and compressive strength of samples aged to equilibrium conditions. Standard compressive strength samples were gassed for 0, 30, and 200 seconds and placed in desiccators containing either a drying agent or water. The samples were weighed periodically, and after 40 days they were tested for compressive strength. The results of the test are shown in Fig. 15.

Gassing time had little effect on the amount of water that was absorbed or removed during the aging period. Most of the moisture in the sand mixtures aged in dry air was removed during the first 24 hr, but a small amount of drying continued up to the end of the test period of 40 days. The samples aged in saturated air continually absorbed water, and after 40 days the sand had absorbed an amount of water equal to the original weight of sodium silicate, 7 per cent. Despite this great increase in moisture content the compressive strength of the weakest specimen, the one gassed for 200 seconds, was still 210 psi.

The compressive strength of the ungassed specimen aged in saturated air was a surprising 390 psi. This anomalous behavior was probably due either to transfer of CO_2 from the gassed samples or reaction with the sugar during the 40 day aging period. The results of these tests indicate that aging sodium silicate bonded sand under ambient conditions can cause as much as a five-fold variation in compressive strength depending on the moisture content of the air and the aging time, and an equilibrium condition may not be attained even after a 40 day period.

In order to eliminate the variable of the moisture content of the air, a series of experiments was conducted under closely controlled drying conditions. Compressive strength samples from sand mixtures containing 5 per cent type B sodium silicate, 1 per cent liquid sugar, and various amounts of added water were dried in an oven held at 110 C (230 F) with dry air circulation.

One set of specimens was not gassed with CO_2 and the other set of specimens was gassed for 60 seconds. The amount of water removed after 2 hr and after 24 hr was determined for the ungassed specimens, and the amount of water remaining in the specimens is shown in Fig. 16. It can be seen that most of the water was removed in the 2 hr drying period. If the water remaining is considered to be all related to the sodium silicate, the water content of the binder itself, after 2 hr drying, was between 23.4 per cent and 36.3 per cent. After 24 hr drying the water content was between 6.8 per cent and 18.4 per cent. Sodium silicates with such water contents are in the regions of semisolids, dehydrated liquids, and glasses (Fig. 4).

The increase in strength resulting from the removal of water is illustrated in Fig. 17. Maximum dry strength was developed after 2 hr of drying at 110 C (230 F) and did not appreciably change with longer drying times. The addition of 0.5 per cent water did not affect the drying time required to attain maximum strength, but the addition of 1 per cent water increased that time about 1/2-hr. The addition of 0.5 per cent or 1.0 per cent water to ungassed sand did not affect the magnitude of dry strength (2000-2800 psi), but 1 per cent water addition decreased sand dry strength which was gassed 1 min.

The sand which had been gassed with CO_2 increased in strength about 200 psi with drying. Samples

gassed for a longer period of time or samples with high ratio silicates would probably have decreased in strength after drying. The humidity of the air during the drying process, even at 110 C (230 F) is very important. Sand that is placed in an overloaded oven or in an oven with limited circulation will not develop the high level of strengths shown in Fig. 17. Hot, dry air blown through the sand can shorten the drying period.

CO_2 AND AIR MIXTURES

The rapid rate at which strength is developed with CO_2 is the prime attribute of sand bonded with sodium silicate. In the preceding experiments it was noted that only a small portion of the CO_2 passing through the sand is actually absorbed at high gas flow rates. Distribution of the gas through the sand is thus the factor most affecting efficient utilization of CO_2, so an attempt to increase the efficiency of CO_2 utilization was made by diluting the CO_2 with air.

Compressive strength gassing time relationships were determined for sand containing 5 per cent type B sodium silicate and 1 per cent liquid sugar at three different flow rates, 0.3 cfm, 0.1 cfm, and 0.05 cfm, of 100 per cent CO_2, 50 per cent CO_2 and 20 per cent CO_2. The gassing times that were required to develop compressive strengths of 100 psi and 200 psi are shown in Fig. 18.

The times required to develop 100 psi and 200 psi compressive strength were little affected by gas flow rates between 28 and 165 cu in. per min per sq in. using 100 per cent CO_2. When the gas contained 50 per cent CO_2, longer gassing times were required, but the increase in time was less than the proportional reduction of CO_2 used (particularly at high flow rates). The effect produced by diluting the CO_2 still further to 20 per cent was dependent on the total flow rate. At low flow rates the gassing times to attain the respective strength levels were increased only 20 to 30 per cent, but at the high flow rates the gassing times were increased about 600 per cent. This apparent anomalous behavior may have been due to a drying action at the high flow rate which would not only reduce the proportion of solvent available, but also increase viscosity. Lower water content at high viscosity would greatly retard the absorption rate of CO_2. However, with proper control for applications not requiring the maximum rate of hardening, dilution of CO_2 with air to concentrations of 50 per cent or even 20 per cent can be used to increase the efficiency of the CO_2 process.

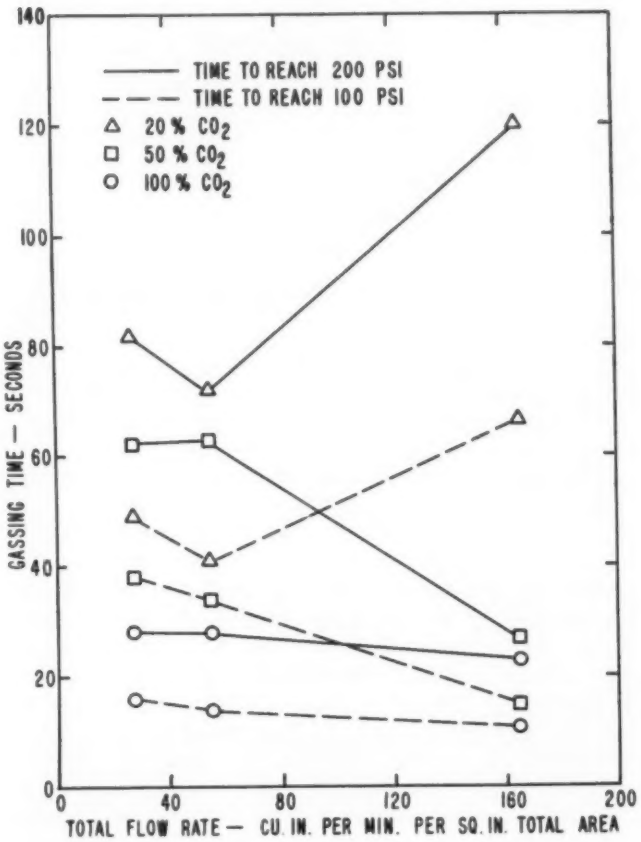

Fig. 18—Effect of CO_2 concentration and flow rate on gassing time to attain 100 psi and 200 psi compressive strength. Sand mixture: 94 per cent silica sand, 5 per cent sodium silicate, with $SiO_2/Na_2O = 2.38$, and 1 per cent liquid sugar.

SUMMARY

The results of this investigation have provided information which may be directly applied to practical applications of the CO_2 process. Implications of immediate practical importance were incorporated in the body of the report, so only the conclusions related to basic parameters will be stated:

1) The rate at which sand mixtures develop strength with CO_2 increases with increase in the SiO_2/Na_2O ratio of the sodium silicate.
2) The maximum gassed strength attained increases with increase in the SiO_2/H_2O ratio of the sodium silicate.
3) The gassed strength of sands bonded with sodium silicate having high SiO_2/Na_2O ratios is limited because the viscosity of high ratio silicates is sensitive to concentration.
4) The dry strength of sand bonded sodium silicate is dependent upon the composition of the sodium silicate and the CO_2 gassing time.
5) The humidity of the air during an aging period has a great effect on the strength of sand bonded with sodium silicates.
6) The efficiency of the CO_2 gassing process may be significantly increased by diluting the CO_2 with air.

REFERENCES

1. Atterton, D. V., "The Carbon-Dioxide Process," TRANSACTIONS, American Foundrymen's Society, v 64, 1956, pp 14-40.
2. Nield, F. W. and Epstein, D., "Application of Sodium Silicate for Bonding Sands," *Foundry Trade Journal*, v 103, No. 2134, September 1957, pp 279.
3. Wulff, C. E., "Is CO_2 Necessary?", MODERN CASTINGS, v 32, August 1957, pp 28-29.
4. Vail, J. G. *Soluble Silicates—Vol. 1*, Reinhold Publishing Corp., New York, 1952.

ACKNOWLEDGEMENT

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NOISE INDUCED HEARING LOSS

By
Eugene L. Walsh, M. D.*

The subject of noise induced deafness is becoming trite; it appears on so many scientific programs. It is the impact of legal attention in compensation claims, the medical interest in the ails of man, and the sincere desire of most employers to produce a "safe place to work" that demands continuance of the inquiry. From the medical viewpoint, deafness due to excessive noise exposure is permanent. The only treatment is prevention. Therefore, we continue our appeal to the industrialist to help in this phase of preventive medicine.

Beside the moral obligation of management to prevent injury, occupational disease, or deafness due to noise exposure, there is also a financial incentive involved. It is true that states which now include occupational deafness in the workmen's compensation schedule require a six months removal from exposure before the amount of compensation will be determined. This is done in order to evaluate the degree of hearing loss and to prevent a flood of claims. Nevertheless it should be borne in mind that any employee who has left his employment for any reason can, after six months from the time of such severance, file a claim for hearing loss.

Since we admit inability to correct the damage to the nerve of hearing once it occurs, you might ask if it is possible to select those who might be noise susceptible. The question could be dodged by stating that man is a polyhybrid animal, living in an environment of innumerable, ever changing, and uncontrollable variables. Therefore, observations of pure cause and effect relationship have a low order of statistical validity. If the question is pursued further, we will say we have some rather elaborate tests which might select the individual more susceptible to noise induced hearing loss. These tests are, however, not absolute, nor are most of them simple enough to be of practical value. So again, we come to the point of prevention of the disorder since selection is improbable. Hence don't count on avoiding preventive control of noise by trying to hire men not noise susceptible.

WHAT IS NOISE?

Before discussing prevention, let us briefly review the problem. First, what is noise? One definition is that "noise is unwanted sound." The unwanted will bear further discussion. Man is a gregarious, adaptive animal. Place him in an anechoic chamber (a soundless room) for some length of time and most will feel isolated, uneasy, insecure, and out of contact. The old adage "silence is deafening" is appropriate. Man has developed in an environment of and accept background noise as a wanted sound. It gives him a sense of contact. Many have Hi-Fi sets and play them to capacity, blatting out as much as 100 decibels of questionable harmony to others, particularly, neighbors. This is unwanted and sometimes even detrimental to good interpersonal relationships.

Why do some of people like the hustle and bustle of the city or a noisy job? Because it satisfies a gregarious urge to be around people. One may even say that some enjoy being a "big noise," at least insofar as a part of a job is concerned. It supports man's ego in being heard. Some workers clamoring for recognition and a sense of power have this quality as an unconscious substitute for action or reaction.

But let us get down to sound business decisions: You will have as much noise control as top management wants. . . . . .no more, no less! And believe it or not, it usually will cost more not to do anything about noise than to do something about it.

You foundrymen know that if you don't do a good cost analysis on each job you'll find yourselves overpricing castings in some cases – thereby pricing yourself out of the job; or you underprice the casting, thus losing money. Only the correctly priced castings keep you in business since you get the order on those but the profit is often cut by the underpriced castings.

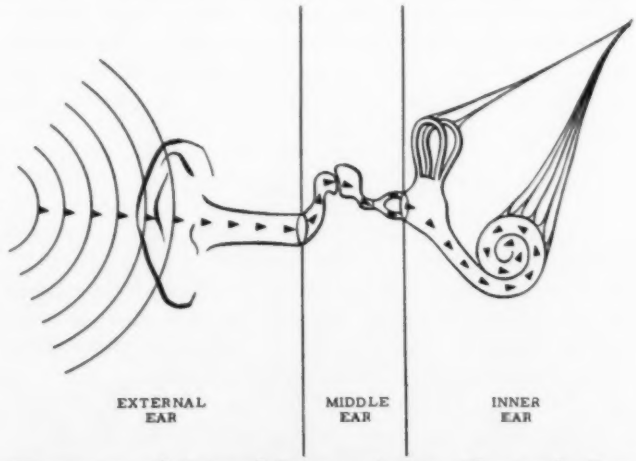


Diagram of Sound Transmission Through Ear

*Medical Director, International Harvester Co., Chicago.

So with noise prevention! Unless you do something about it, you will pay later in direct costs for noise deafness; and you are probably paying now indirectly – just as with the underpriced casting.

Prevention of noise induced deafness is a teamwork problem. It requires an enlightened management to support the program, engineering ability to design equipment, technical specialists to evaluate the problem, and physician specialists to determine the effect on man; and, of course, attorneys and legislators to form regulative orders to "crack the whip" and get the program underway.

WHY BE INTERESTED IN NOISE?

Industry is geared to production. In keeping with providing a safe place to work, industry must reduce hazards to the irreducible minimum in order to increase production.

One cannot process solid materials, or even liquid or gaseous materials, without producing some form of vibrating energy. In the case of noise, we are interested in damage risk levels; that is, how much noise is the maximal safe exposure before damage to man's hearing apparatus occurs. The human ear is a delicate receiving apparatus, translating the mechanical energy of sound into nerve impulses. The impulses travel to the brain where we recognize in consciousness the particular qualities and interpret them on the basis of past experiences.

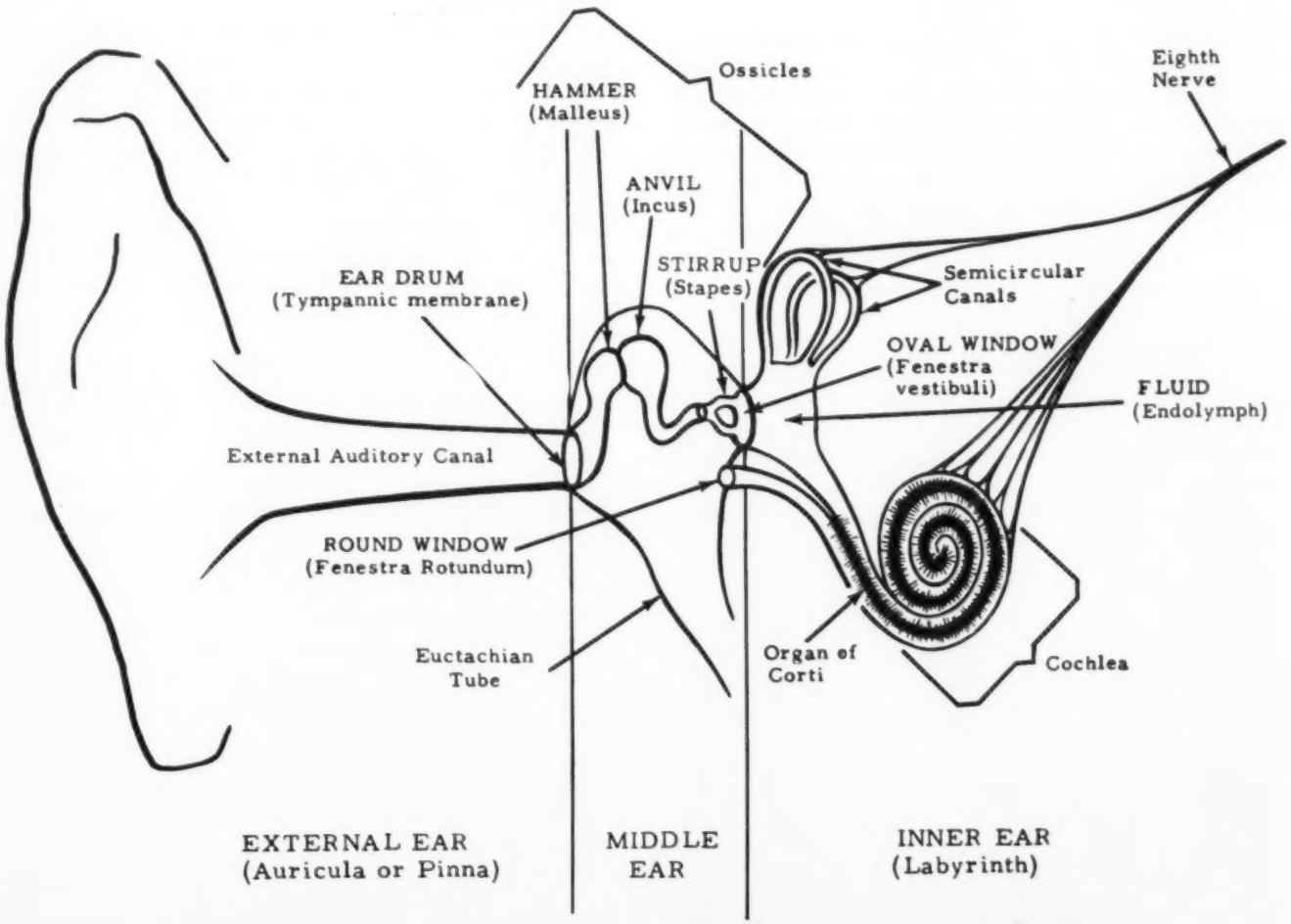
Sound waves are pressure waves. The normal ear is capable of recognizing pressure variables of the magnitude of one billionth of an atmosphere* Sound is measured in decibles, a scale which is a convenient logarithmic progression of increasing energies. Doubling the sound level represents only a 3-decible increase. In general, sounds of less than 85 decibels cause no harm. Intensities above this may cause damage to hearing. Above 130 decibels, pain is produced in the ear. High frequency sounds (high pitched), in general, are more damaging than low frequencies (low pitched).

To produce damage to the hearing apparatus, energies of different types and duration must be considered. A single blow of mechanical energy to the head may damage the hearing mechanism by disruption of bone or of the hearing mechanism, or by hemorrhage. A single blast of 140 decibels or more of an explosion may irrevocably damage the hearing mechanism. Long continued exposures to air borne noise of 85-100 decibels may be damaging. For bone conduction (noise passing to the inner ear through the bone surrounding ear) levels are 20 decibels higher.

EFFECTS OF NOISE

This is the problem for discussion today. The effects of noise on man depend on: 1) loudness, 2) fre-

*An atmosphere is a pressure equal to 14.7 lb/in.²



Schematic Diagram of Anatomy of Ear

quency of vibration, 3) the hours per day and the duration in years of exposure, 4) the distribution of the noise – is it continuous or interrupted, and 5) the susceptibility of the individual. For our purposes, we shall not elaborate further than to say that usually we are concerned with high-level noise and years of exposure. The details have been elaborated in numerous articles, including the FOUNDRY NOISE CONTROL MANUAL of the American Foundrymen's Society. A preliminary release of this material was distributed at your meeting last year.

In the ordinary business office with an overall sound level of 50-60 decibels, the spoken voice is heard within about 8 ft. If you have to shout at any work location to be understood, you probably have a noise problem and should investigate. This indicates a noise level of about 90 decibles. If employees have temporary head noises or ringing in the ears on leaving work or if they have a temporary threshold shift of hearing (a period of partial deafness from which recovery is complete in a few hours), it is time to begin a program of hearing conservation.

A program of hearing conservation or noise control is a teamwork problem, the medical phases of which might be briefly classified. First there should be an audiometric survey of employees. *Not all loss of hearing is noise induced.* Of new applicants for work, one might expect to find on an audiometric survey 75 per cent with normal hearing, 10 per cent with a moderate loss of hearing, 5 per cent with a severe loss, and 10 per cent with a loss in one ear only.

Unless one has a pre-employment audiometric examination, one does not have a base line for comparison to evaluate possible damage. Thus unless you have a program of pre-employment audiometric examinations, you may be buying an already existing hearing loss. The audiometric record will prevent paying later for a hearing loss not sustained in your plant.

AUDIOMETRIC EXAMINATION

The audiometric examination must be done in fairly quiet surroundings (less than 40 decibels), otherwise, sound reception may be impaired or confused. The spoken voice or watch ticking test of hearing is totally unreliable since the first effects of noise induced deafness occur near the 4000 cycle per second frequency and the speech interpretation level is condiderably lower. We shall not enter the discussion of the various types of audiometric examinations such as the full scale; the screening type at one frequency only, with a full record only on those indicated; the pure tone versus speech audiometry, etc. Each of these has advantages in certain circumstances.

The program of pre-employment audiometry must be followed by periodic re-examination of hearing at 3-12 month intervals, depending on the noise exposure.

The factors of other disease conditions affecting hearing, of prebycusis (the impairment of hearing due to deterioration of the normal aging process) must be recognized.

A noise survey of the work area is an integral part of the program. This must include overall noise levels and the octave-band composition in designated areas. The duration and distribution of noise levels and exposure during a typical work day must be noted. The survey must designate the intensity and duration of exposure at the employees work area during normal work conditions, if it is to have meaning. The employees' work record must be known to indicate the total exposure during the work life.

When critical noise levels are found, and continuous long-term worker exposure occurs, engineering control measures are indicated.

As with any hazard, the ideal method of control is to eliminate the problem at its source. Redesign of equipment with fewer striking or vibrating parts, substitution of non-vibrating materials for metallic parts, isolation of the process, timing a process to off-shift times, automation, or use of sound-absorbing or deflecting media, any or all may be used to reduce noise production.

If engineering and environmental-control measures fail to eliminate the hazard, personal protective measures may be considered. Rotation of personnel, so as to reduce the total exposure time, can be considered but other solutions are usually better. The use of ear plugs or ear muffs or both by the worker may reduce the noise level at the ear to tolerance levels.

In conclusion, I hope this hasty and incomplete review of the noise problem has highlighted some areas of interest. A successful noise hazard elimination program must have primarily the active interest and participation of management.

While it is desirable to have the help of an engineer, hygienist and physician, any foundry of itself can do much to control noise. Technical advice is available through AFS.

If we want it so, "The Foundry is a Safe Place to Work," whether we consider noise or any other health hazard.

FOUNDRY APPLICATIONS OF THE CALCIUM CARBIDE INJECTION PROCESS

By

W. R. Lysobey* and A. E. Tull**

INTRODUCTION

The calcium carbide injection process, first conceived about 1949, is a new concept when considered with other processes of the iron and steel industry. Since 1949, great strides have been made in improved equipment design and new applications.

The principle of solids introduction into molten iron by the injection process is relatively simple. The solid is carried by nitrogen, an inert gas, through a suitable conveyance system below the surface of the metal. The solids-metal reaction occurs as the solid rises to the surface of the metal.

In its earliest stages the calcium carbide injection process was primarily considered for use with the production of ductile iron. It is a valuable tool for lowering the sulfur in acid cupola iron to low levels (less than 0.02 per cent sulfur, prior to reladling the metal onto magnesium bearing alloys and ferrosilicon alloys). The results of pretreatment with calcium carbide injection before magnesium alloy addition will provide considerable savings in the cost of magnesium alloys.[1,2]

Another variation of this process in producing ductile iron is to inject a mixture of calcium carbide and pure magnesium into iron which was melted in an acid or basic cupola.[3] It indicates another means of introducing magnesium into cast iron at low cost compared to the conventional method of tapping or reladling iron onto magnesium bearing alloys.

Another facet of calcium carbide injection involving formation of nodular or spherulitic graphite is by injecting mixtures of calcium carbide, magnesium oxide and rare earth oxides.[2] This is a specialized application of the process which has had limited use.

The majority of the cast iron production in this country is gray iron containing graphite of the flake variety, so this discussion is confined to the applications of the calcium carbide injection process to this type of iron. This treatment of the subject will show that the reaction of calcium carbide with molten cast iron will produce graphitizing. It will also show inoculating effects similar in many respects, yet unique in others when compared to more familiar inoculating techniques.

EQUIPMENT

As the injection process evolved, suitable equipment to handle the process operations in foundries was developed. One of the earliest types is the batch feeder depicted in Fig. 1. This equipment is simple and reliable. With the batch feeder, calcium carbide is injected from the hopper directly into the metal through the graphite injection tube. This equipment may be modified so the injection tube may be raised and lowered independently of the normal 50 lb hopper. A flexible hose is attached between the hopper and the graphite tube for this purpose.

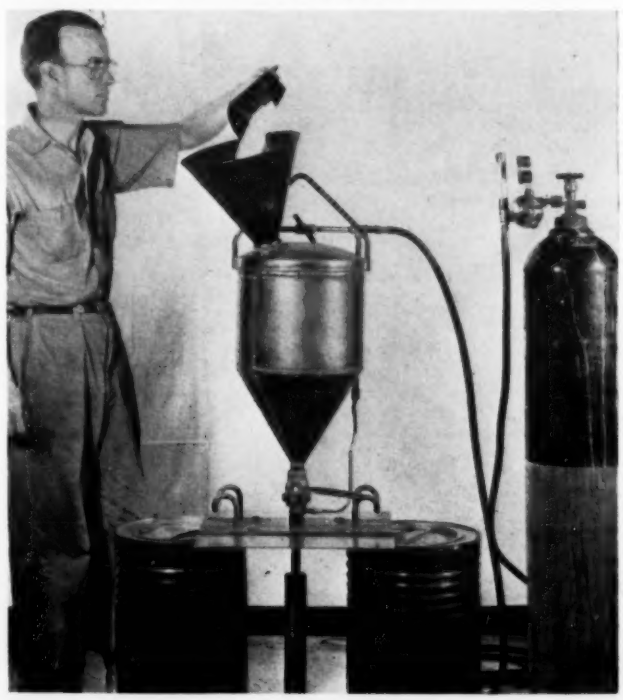


Fig. 1 — Injection apparatus, batch type.

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**Metallurgical Engineer, Air Reduction Sales Co.

There are two foundry installations currently in operation where 500 lb capacity hoppers of this design have been mounted on the charging platform. A conveyor line carries the solids and gas from the hopper to the graphite injection tube.

The CaC_2 travels essentially in a downward direction. Low pressures are used in the hoppers and a minimum of conveying gas is required. This low gas flow will result in keeping the metal splash and agitation to a minimum.

For installations where material must be transported through a hose in a horizontal or upward direction, a special type of equipment called a fluidizer (Fig. 2) has been developed. This requires higher gas pressures. Equipment has been developed for this purpose to comply with the A.S.M.E. Code requirements for pressure vessels.

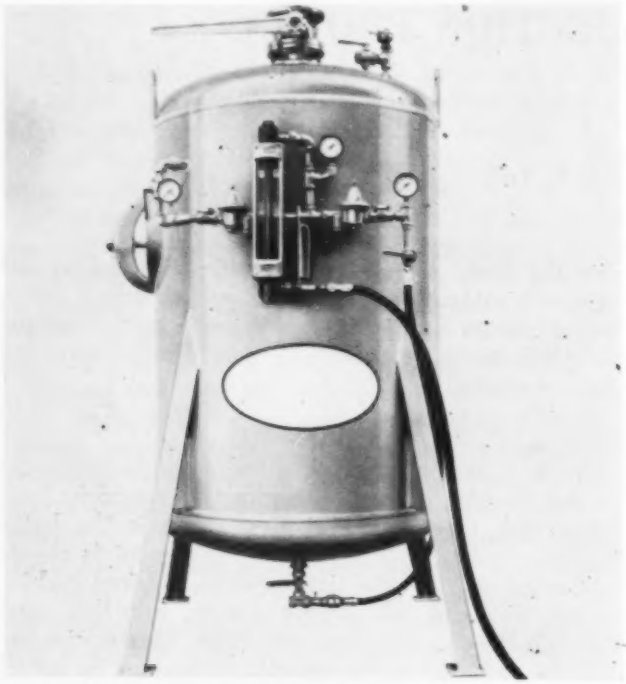

Fig. 2 – Injection apparatus, fluidizer type.

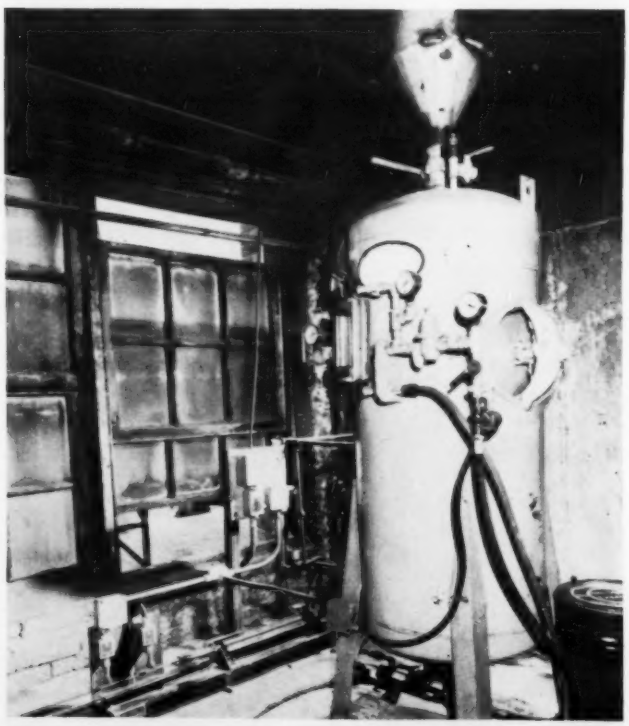

Fig. 3 – Carbide injection equipment for automatic continual treatment.

Calcium carbide or other material is loaded through a top filling valve. The nitrogen supply line is connected to a flow meter so the carrier gas flow is precisely controlled. Part of the metered gas passes through a pressure regulator and is used to regulate the tank pressure. The other portion passes through another regulator controlling the amount of dilutor or carrier gas added to the calcium carbide in the conveying line.

The pressure setting on the hopper will determine the rate that calcium carbide will feed from the fluidizer. The dilutor gas is set to provide a sufficient quantity of gas to smoothly transport the material through the line and below the surface of the molten metal bath.

Figure 3 shows a completely automatic installation where the iron is continually treated on an intermittent basis. A timer, solenoid control valves, and raising and lowering device for inserting and withdrawing the graphite injection tube, make it possible to treat metal produced automatically.

Figure 4 shows a typical treating bath into which calcium carbide is injected.

APPLICATIONS AND RESULTS

The major portion of the data presented here was obtained in operating foundries where this process is being used. The data is therefore not as precise and complete as that obtained in a laboratory. In an effort to span the broad area of foundry applications of this process, the authors have taken the liberty of reporting the results in the form of case histories.

The first practical demonstration on a production scale was demonstrated by a gray iron foundry several years ago. This operator was producing small

Fig. 4 – Metal treatment bath.

castings for a hardware manufacturer. He encountered difficulties in producing castings machinable in thin sections. In addition, upon drilling and tapping one of the heavier sections of this casting, the purchaser was encountering porosity.

This iron was treated with seven lb calcium carbide per ton, lowering the sulfur content from 0.090 per cent to 0.060 per cent. The treatment was varied on a day to day basis depending on chill depth obtained by pouring a simple wedge test.

This treatment was effective in preventing the formation of white iron in thin sections, and benefited in producing improved microstructures (Fig. 5, 6).

Figure 5 is a photomicrograph of an untreated 3/16-in. section. The occurrence of preferred oriented Type D and E graphite in a matrix of 50 per cent pearlite–50 per cent ferrite is shown. This type of structure is considered poor from a machinability point of view. This is due to the fact that the tool has a tendency to dig into the ferritic areas while machining normally over portions of the pearlitic areas.

The photomicrograph (Fig. 6) was taken from the same location of a treated casting. The graphite has been transformed from Type D and E to Type A and B. The matrix has been transformed from 50 per cent pearlite to approximately 75 per cent pearlite.

This is not considered the optimum microstructure. The improvement in structure, with reduction of chill formation in thin extremities of the castings, was sufficient to insure good machinability in this case. The result of the CaC_2 treatment was to reduce chill, transform the graphite into a more desirable form, and to promote the formation of pearlite.

The eventual consumer of these castings has materially increased the rate of machining on castings of this type. Another interesting observation was the decrease in shrinkage porosity in the heavier sections.

The authors hesitate to explain the mechanism by which inoculated iron feeds into the mold better than untreated iron. However, it has been observed that the soundness of iron is associated with Type A graphite in a pearlitic matrix.

A good example of this was recently discovered in a foundry producing castings for the automotive industry. Here the foundry was experiencing high rejection rates due to shrinkage porosity. This defect was occurring in bosses and other places in the casting where heavy sections were adjacent to thin sections.

This situation was due to the hardness specifications imposed by the purchaser of the casting. The specifications could be met only by melting a near eutectic composition. After the carbon and silicon compositions of the cupola iron were increased in order to meet the hardness specifications, the rejections from shrinkage porosity increased at an alarming rate. Some of this shrinkage was internal. It was not detected until the castings were machined at the purchaser's plant some 600 or 700 miles away.

It was first intended to use calcium carbide injection to reduce Brinell hardness in the castings poured from the original cupola mix (hard mix). This composition offered few problems in porosity. However, in setting up the equipment, the initial injections of calcium carbide were performed on the soft mix. It was learned, at this time, that the calcium carbide treatment had the effect of eliminating the shrinkage defects. The chemical analysis of this iron appears below:

% C	% Si	% Mn	% P	% S	C. E.
3.45	2.35	0.58	0.20	0.100	4.30

Fig. 5 – Representative microstructure in 3/16-in. section in untreated iron. Type D and E graphite, estimated 50 per cent pearlite matrix. 100×.

Fig. 6 – Microstructure in 3/16-in. section in CaC_2 treated iron. Type A and B graphite. Matrix consists of 75 per cent pearlite, 25 per cent ferrite (est.). 100×.

Prior to calcium carbide injection, this foundry rejected about 117 castings per day. The present average rejection rate with this defect is from two to five pieces a day.

Examination of microstructure before and after calcium carbide treatment, indicated a pattern which was becoming familiar. The iron before treatment showed the occurrence of D and E interdendritic graphite with high percentage of ferrite in the matrix. After treatment, the graphite was essentially Type A in a pearlitic matrix.

It was interesting to note, upon reviewing Brinell hardness data taken from step bars poured hourly, that there was a marked tendency to decrease section sensitivity in the treated bars. In fact, it was not unusual to find step bars which exhibited the same Brinell readings on all three steps (1/4-in., 1/2-in., 3/4-in.). This decrease in section sensitivity also appears in hypoeutectic irons subsequent to calcium carbide treatment.

This foundry utilizes an automatic treating installation similar to that shown in Fig. 3 and 4, to inject approximately four to six lb calcium carbide per ton of iron. This treatment reduces the sulfur from an average of 0.10 per cent to an average of 0.07 per cent. The amount of material injected is controlled on the basis of chills poured every half hour.

The cost of treatment has been more than offset by the improved flowability, or castability, and has permitted the removal of risers from some castings. This has resulted in a greater yield of castings. This benefit, of course, is in addition to the original problem of shrinkage porosity which has been essentially eliminated.

Another application arose recently for CaC_2 treatment where the sole purpose was to maintain the sulfur level below 0.10 per cent to meet a government specification. The chemical analysis of this iron appears below:

% C	% Si	% Mn	% P	% S	C. E.
3.64	2.64	0.57	0.32	0.127	4.62

Utilizing the automatic installation technique, this iron was treated with calcium carbide to effect a reduction in sulfur content from an average of 0.12 per cent to 0.08 per cent.

The microstructure shown in Fig. 7 is typical of untreated iron. It contains a matrix of approximately 50 per cent pearlite–50 per cent ferrite (estimated). The graphite formation is predominantly Type A. However, there is a considerable amount of fine, close network-type graphite associated with the ferrite areas.

The microstructure depicted in Fig. 8 has a uniformly sized and distributed Type A flake in a 100 per cent pearlitic matrix. This foundry has reported an improvement in machinability of the castings made from inoculated iron in terms of increased tool life.

A slightly different variation of calcium carbide application was illustrated in a foundry pouring castings for the water works industry. A typical chemical analysis of this iron is as follows:

% C	% Si	% P	% Mn	% S
3.25–3.30	1.80–1.85	0.30–0.35	0.45–0.50	0.10–0.12

The majority of castings produced in this shop possess at least a 1/4-in. section thickness. However, many thin extremities exist which require a machining op-

Fig. 7 — Microstructure in untreated iron containing 0.127 per cent S, predominately type A graphite in approximately 50 per cent ferrite, 50 per cent pearlite matrix. 100×.

Fig. 8 — Microstructure in CaC_2 treated iron containing 0.073 per cent S, type A graphite in completely pearlitic matrix. 100×.

eration. Difficulty in machining these sections was a constant source of trouble which had not been completely relieved by the addition of conventional inoculating alloys.

This iron is treated with approximately seven lb calcium carbide per ton of iron, lowering the sulfur content from an average of 0.10 per cent to an average of 0.06 per cent. The treatment has been sufficient to consistently suppress the occurrence of hard iron in thin extremities.

The cost of calcium carbide injection was more than offset at the cupola itself. The operator was able to substitute calcium carbide injection for the use of soda ash desulfurizer in the ladle, plus FeSi inoculation in the ladle. In addition, he was able to eliminate the use of manganese, silicon carbide, and proprietary spar briquettes in the cupola charge. Reviewing average physical test results before and after calcium carbide treatment, the average tensile strength in a 1.2 in. bar before calcium carbide injection was 34,200 psi. After the process was used for a period of time, the average tensile strengths were 37,500 psi.

In this plant the treatment is performed in a conventional U-type tilting holding ladle with a batch feeder type dispenser mounted on the cupola charging platform. The calcium carbide is transported in a downward direction through the 1/2-in. I. D. hose attached to the graphite injection tube. This is manually raised and lowered into the ladle throughout the day's production. The treatment is performed and controlled by the ladle man who is guided by chill wedges poured from each 3000 lb capacity transport ladle.

A foundry pouring a hypoeutectic iron of a higher carbon content, but lower silicon content, demonstrates a benefit associated with this type of inoculation. This shop normally produces a 40,000 tensile strength iron of the following chemical analysis:

% C	% Si	% Mn	% P	% S	C. E.
3.45	1.35	0.50	0.35	0.11	4.01

The primary difficulty encountered in this shop was associated with internal porosity in large pulley sheaves. This porosity would invariably appear at or near the intersection of the spoke and the rim. Normally it would not be detected until grooves were machined some distance into the rim.

The inoculating effect of calcium carbide changed an iron prone to Type D graphite into an iron containing predominately Type A in a pearlitic matrix. In transforming the iron structure the internal porosity has, for all practical purposes, been eliminated.

The foundry operator has found it possible to pour this higher strength calcium carbide treated iron into castings where it was only possible to use a near eutectic composition. This enables the foundry to upgrade the strength and maintain machinability in many thin sectioned castings.

In our laboratory, test castings have been poured from low carbon, low silicon iron to investigate the effect of inoculation on the casting characteristics of iron. The composition of this iron appears below:

% C	% Si	% Mn	% P	% S
3.15	1.37	0.60	0.18	0.10

The castings poured with untreated iron showed external shrinkage. Upon x-ray examination it exhibited internal porosity in the areas immediately adjacent to an increase in section size. External examination of the calcium carbide treated castings showed they were sounder. The x-ray examination disclosed no internal porosity. This is an improvement in castability of iron using this type of inoculating technique. It has converted Type D and E graphite, ferrite-pearlite matrix into predominately Type A graphite in a wholly pearlitic matrix. This casting is shown in Fig. 9. This casting was chosen by the authors and their colleagues because they felt that it would provide some information concerning the castability characteristic of the iron.

It is not thought by the authors that iron of this low carbon equivalent would normally be poured into a casting possessing such thin sections. However, subsequent to the calcium carbide treatment, a drastic change in hardness levels was evidenced. The hardnesses of the untreated castings opposite point A (7/8-in.), B (7/8-in.), and C (3/16-in.) are 276 BHN and 341 BHN and 294 BHN respectively.

After treating the metal to lower the sulfur to 0.054 per cent, it was noted that the Brinell hardnesses of this casting were respectively 225 BHN, 232 BHN, and 221 BHN. This seems a good example to show that section sensitivity of cast iron can be diminished by the use of the proper inoculation techniques.

One of the most interesting variations of this process has been developed during the past year. The authors were fortunate enough to work with a foundry that is producing a centrifugally spun casting with the iron poured against a rotating metal mold. Specifications of this casting call for a minimum chill in the iron surface which contacts the metal mold surface. A completely pearlitic matrix containing Type

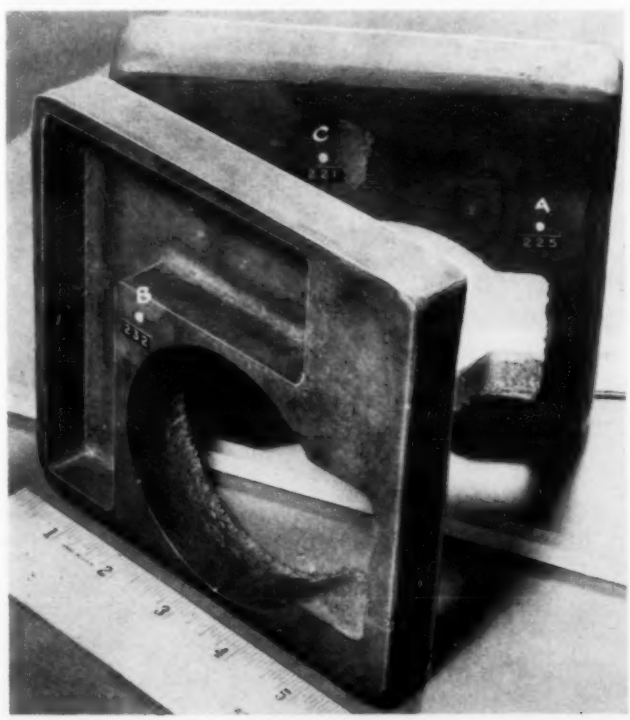

Fig. 9 — Experimental casting used in laboratory investigations. Mirror view shows hardness readings on drag side. CaC_2 treated.

Fig. 10 — Microstructure in sand-cast test specimen. Type D and E interdentritic graphite. Matrix is pearlitic with some areas of ferrite in evidence. Sulfur content 0.14 percent. 100×.

Fig. 11 — Microstructure in sand-cast test specimen. Predominately type A graphite in completely pearlitic matrix. Sulfur content 0.017 per cent. 100×.

A graphite is specified on the internal diameter after a machining operation has removed approximately 1/8-in. of metal. As a result, the foundry melts a soft iron with the analysis appearing below:

% C	% Si	% Mn	% P	% S	C. E.
3.50	2.40	0.65	0.075	0.11	4.32

A high carbon equivalent iron is melted to minimize chill formation on the back side of the casting. Solidification of the metal under these conditions is extremely rapid. This aggravates the formation of the areas of Type D graphite in a ferritic matrix. Cause for rejection of castings was poor service life expectation. After experimentation, it was found that minimum chill and a wholly pearlitic matrix containing Type A graphite is produced by desulfurizing the iron with CaC_2 to less than 0.03 per cent sulfur.

Figure 10 depicts the structure of this iron as received from the cupola when poured into a sand cast cylinder test pin about 2 in. long x 0.8 in. in diameter. As can be seen by examining the untreated iron shown in Fig. 10, D and E, interdentritic graphite and areas of ferrite exist. This iron would be poor for wear and thermal shock service.

Figure 11 is a photomicrograph of the same iron, poured into the test pin described above, after treatment with 19 lb calcium carbide per ton. The sulfur content has been lowered from 0.14 per cent in the untreated iron, to 0.017 per cent in this iron. The graphite is essentially Type A while the matrix is wholly pearlitic. This type of structure has proven in service to be a good wear resistant iron. It has performed well under conditions of severe thermal shock.

Figure 12 is a microstructure of the casting itself which solidifies at a more rapid rate than the previous two samples. Again, predominately Type A graphite is contained in a 100 per cent pearlitic matrix.

Previous work had been done by this foundry in producing this structure by the addition of various alloying elements such as molybdenum, tin and a whole range of alloy inoculants with varying degrees of success. Most of the inoculant techniques which involve the use of metallic alloys would not produce the minimum chill in conjunction with a pearlitic matrix and Type A graphite.

RELATIONSHIP OF CHILL TO MICROSTRUCTURE

The authors have reviewed some of the past laboratory work with the calcium carbide injection process to define the relationship between sulfur reduction and chill reduction.

In Fig. 13, left to right, are shown samples of base iron, and samples of chills taken after incremental injections of calcium carbide in an induction furnace. This is a hypereutectic composition. The heat was held in the furnace and chill bars and 1.2 in. test bars were poured after each injection of CaC_2.

The effect of the first three treatments was to lower the chill forming tendencies of the iron. After the fourth injection, a definite reversal in this tendency is observed. The base iron contained 0.153 per cent sulfur, and after the third treatment, the sulfur was lowered to 0.064 per cent. Thus, a minimum chill

value for this particular iron is obtained by lowering the sulfur from 0.153 per cent to 0.064 per cent.

This suggests that the minimum chill value is a function of sulfur removal rather than the final sulfur level. It is expected that the minimum chill value of a similar composition cast iron, if melted with a 0.10 per cent base sulfur, would appear at a lower sulfur level than this particular iron.

The photomicrographs of the iron shown in Fig. 14 relate to the chill samples in Fig. 13. They were taken from the 1.2 in. bars poured along with the chill specimens. Figure 14a shows the structure obtained in the test bar when the minimum chill value was obtained. The graphite in Fig. 14a is Type A in a completely pearlitic matrix. Figure 14b relates to chill sample No. 4. It is felt that this increment of desulfurization has resulted in an increase in chill. The sulfur at this stage is 0.025 per cent. The photomicrograph shows that ferrite is beginning to form adjacent to the graphite flakes, although the graphite is still essentially Type A.

Figure 14c shows the microstructure in sample No. 5 which has been desulfurized to 0.009 per cent. The graphite has been transformed into Type D with a predominately ferritic matrix.

LABORATORY INVESTIGATIONS

Recently in the authors' company laboratory, the inoculating effect of calcium carbide injection was studied wherein the treatment was performed on low carbon, low silicon irons. In this work, the iron was melted in a 500 lb induction furnace. The aim analysis was 3.10 per cent C, 1.40 per cent Si, and approximately 0.09 per cent S.

In this work an investigation was made of the effect of calcium carbide inoculation upon microstructure, tensile strength and hardness levels in varying section sizes. In Table 1 it can be seen that the tensile strength of the base iron was 39,500 psi in a specimen obtained from a 1.2 in. bar. The hardness reading was 235. After a calcium carbide treatment of 15 lb per ton of iron, the sulfur content was lowered to 0.054 per cent. No other changes in chemistry were detected.

This iron was poured into 1.2 in. bars, step bars, and into a small test casting shown in Fig. 9. Chill pins were poured for chemical determinations. The

Fig. 12 — Microstructure appearing in CaC_2 treated centrifugally spun, permanent mold casting. Predominately type A graphite in 100 per cent pearlitic matrix. 0.02 per cent S. 100×.

TABLE 1 — INDUCTION FURNACE HEAT NO. 1241

As Melted, %		Injection Treated,%*	
T.C.	3.15	T.C.	3.17
Si	1.37	Si	1.40
S	0.100	S	0.054
C.E.	3.67	C.E.	3.70
Chill Depth			
41/32 in.		13/32 in.	
Average Mechanical Properties in 1.2 in. Diam. Bars			
Trans. B. L.	2150 lb	Trans. B. L.	2660 lb
U. T. S.	39,500 psi	U. T. S.	48,300 psi
B H N	235	B H N	235

*Calcium carbide 15 lb per ton

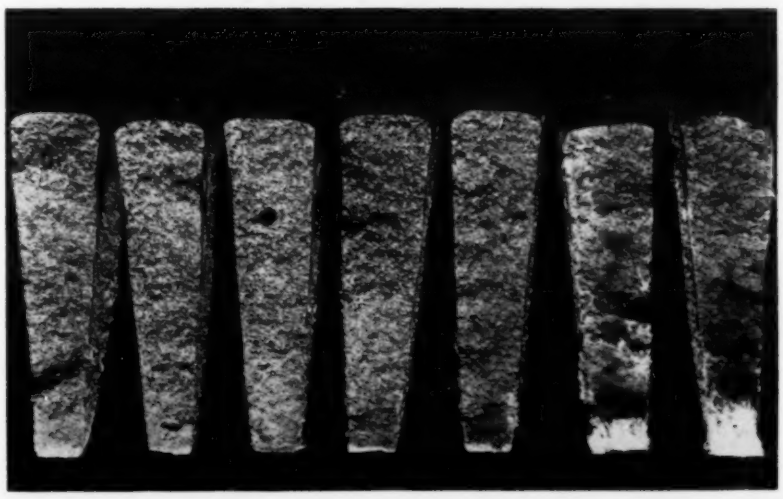

Fig. 13 — Chill bar samples. Left to right, base iron and treated iron after incremental injections of CaC_2.

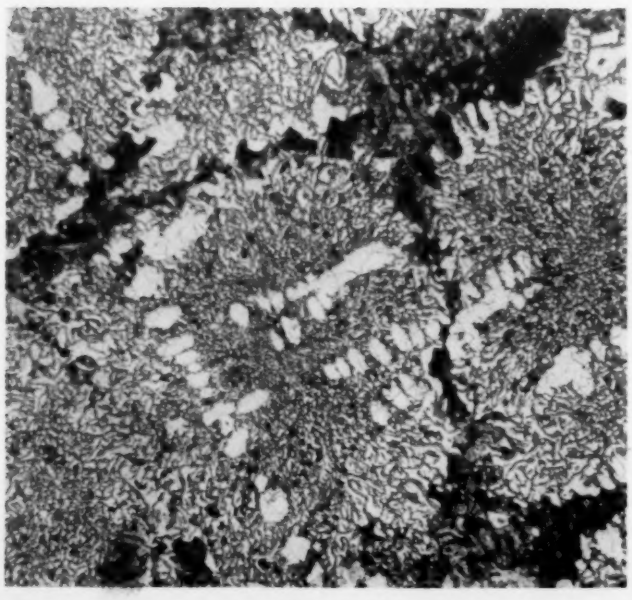

Fig. 14 – Change in microstructure in 1.2 in. bar with progressive desulfurization. 100×.
A – Upper – Desulfurized to 0.064 per cent S by CaC_2 injection. Type A graphite, pearlitic matrix.
B – Center – Desulfurization to 0.025 per cent S Type A graphite, ferritic envelopes around flakes.
C – Lower – Desulfurization to 0.009 per cent S Type D graphite, predominately ferritic matrix.

data in Table 1 show that the tensile strength after treatment was 48,300 psi and the hardness was 232 Brinell. All 1.2 in. bars were shaken out at approximately 1500 F.

The hardness readings which were taken on the 1.2 in. bars do not truly reflect the difference between the treated and the untreated iron. This point is shown in Fig. 15 which is a plot of the hardness readings taken on the step bars. It is apparent that the hardness values are constantly lower in the inoculated iron. In addition, the difference in hardness readings, between the treated and untreated iron, become increasingly greater when comparisons are made in the thinner section sizes.

On the 1/4-in. step, it is observed that the hardness readings range from 290 to 321 to 401. These readings are taken on a line from the center towards the corner of the 1/4-in. step. The respective readings for the same thickness on the treated iron were 247, 245, and 261. This information shows that an effective inoculating technique can produce a high strength unalloyed gray iron which can be machined in relatively thin sections.

In Table 2 are data from a heat of similar hypoeutectic composition treated with a mixture of calcium carbide and magnesium powder. This heat demonstrates that equivalent results are obtained with one-half the amount of calcium carbide if a small quantity of magnesium is incorporated in the treatment.

The authors believe calcium carbide injection in cupola melted iron of similar analysis would result in somewhat better physical properties. In Table 3 are data from a heat of cupola iron melted with 75 per cent steel in the charge. The composition of the base iron was 3.17 per cent carbon, 1.63 per cent silicon, and 0.12 per cent sulfur. After calcium carbide injection the sulfur content was 0.024 per cent. Physi-

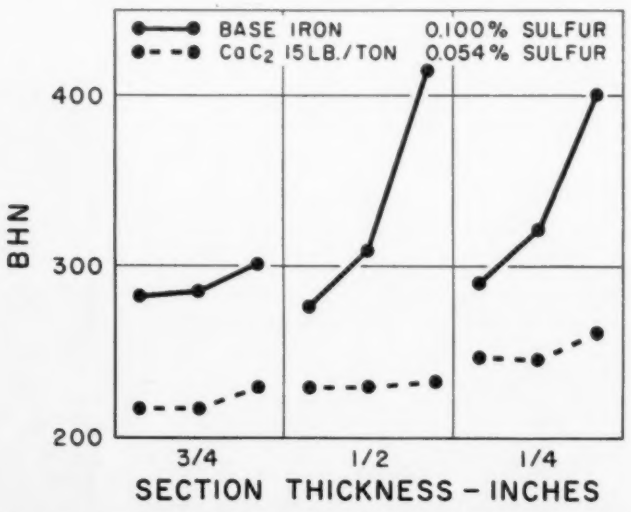

Fig. 15–Step bar BHN vs. section size induction furnace heat No. 1241.

cal properties obtained from 1.2 in. test bars were reported as 50,930 psi T. S. with 229 BHN. It is observed that a higher tensile strength is produced in an iron with slightly higher carbon equivalent than was obtained in the induction furnace heats made in the laboratory.

In order to simulate cupola melting in an induction furnace, a test was run where the melt-in carbon was lower than the carbon level used in the previous induction furnace work. The same final carbon equivalent was reached by injecting a mixture of CaC_2 and carbon.

Table 4 shows the physical properties obtained in a 1.2 in. bar treated in this fashion. An iron with 52,500 T.S. was produced by this treatment. While this data shows that this CaC_2-carbon mixture will increase the strength of an uninoculated base iron from 36,000 psi T.S. to 52,500 psi T.S.

It should not be expected that the same percentage increase in strength will result from similar treatment of cupola melted iron. The reason for this is evident when it is realized that higher strength values are normally expected from untreated cupola iron than from untreated induction furnace melted iron. The experience with CaC_2 injection reported by T. H. Burke[4] lends support to this contention.

CONCLUSIONS

In summary, the authors conclude that better cast iron will result from good inoculating techniques. An effective inoculant will lower the chill forming tendency of cast iron. It will promote the formation of Type A graphite in a pearlitic matrix.

The presence of Type D graphite in combination with ferrite is a clue to many of the problems encountered in cast iron founding. This structure is often coupled with white iron or chill formation in adjoining areas which undergo rapid cooling. Many of the difficulties associated with porosity and shrinkage can be eliminated or greatly lessened by incorporating techniques to produce iron that has Type A graphite and a pearlitic matrix.

The injection of calcium carbide in cast iron will reduce chill formation and promote the formation of Type A graphite in a pearlitic matrix.

The extent of the calcium carbide injection treatment required to produce the optimum physical properties and microstructure will depend upon iron composition and solidification rate.

ACKNOWLEDGEMENTS

The authors are indebted to the personnel of many foundries which participated in developing new applications for the CaC_2 injection process. The advances that have been made with this process are due in a large part to their understanding of cast iron metallurgy, and their ingenuity in adapting this inoculating technique to their melting operation. The authors wish to thank J. G. Billenberg and J. W. Estes of the Air Reduction Research Laboratory for their valuable assistance in this work.

TABLE 2 – INDUCTION FURNACE HEAT NO. 1240

As Melted, %		Injection Treated,%*	
T.C.	3.03	T.C.	3.16
Si	1.36	Si	1.38
S	0.103	S	0.065
C.E.	3.54	C.E.	3.68
Chill Depth			
42/32 in.		10/32 in.	
Average Mechanical Properties in 1.2 in. Diam. Bars			
Trans B. L.	2280 lb	Trans. B. L.	2620 lb
U. T. S.	40,600 psi	U. T. S.	47,300 psi
B H N	235	B H N	238

*Calcium carbide 7.5 lb per ton
Plus magnesium metal 0.4 lb per ton

TABLE 3 – FOUNDRY CUPOLA IRON

As Melted, %		Injection Treated,%*	
T.C.	3.17	T.C.	3.22
Si	1.63	Si	1.64
Mn	0.94	Mn	1.00
S	0.120	S	0.024
P	0.15	P	0.13
C.E.	3.76	C.E.	3.81
Mechanical properties in 1.2 in. Diam. Bar			
U. T. S.	44,140 psi	U. T. S.	50,930 psi
B H N	223	B H N	229

*Calcium carbide 30 lb per ton

TABLE 4 – INDUCTION FURNACE HEAT NO. 1230

As Melted, %		Injection Treated,%*	
T.C.	290	T.C.	3.26
Si	1.41	Si	1.35
S	0.103	S	0.019
C.E.	3.40	C.E.	3.74
Chill Depth			
52/32 in.		28/32 in.	
Mechanical properties in 1.2 in. Diam. Bar			
Trans. B. L.	Not Taken	Trans. B. L.	3240 lb
U. T. S.	Not Taken	U. T. S.	52,500 psi
B H N	Not Taken	B H N	239

*Calcium carbide 30 lb per ton
Plus coke 10 lb per ton

REFERENCES

1. H. E. Henderson and J. M. Crockett – *Foundry, Vol. 81 No. 4* April 1953, p. 86.
2. G. P. Dahm, H. C. Barnes and C. E. Bieniosek, "Fluidization-Injection Process for Desulfurizing and Upgrading Cast Iron," AFS Transactions, *Vol. 63*, 1955 pp 511-520.
3. P. W. Estes and R. Schneidewind, "High Strength Cast Irons Produced by Injection Methods," AFS Transactions, *Vol. 63*, 1955 pp 541-552.
4. T. H. Burke, written discussion, AFS Transactions, *Vol. 63*, 1955 pp 531-532.

PERFORMANCE OF CHILLS ON HIGH STRENGTH MAGNESIUM ALLOY SAND CASTINGS OF VARIOUS SECTION THICKNESSES

By

Merton C. Flemings*, Richard W. Strachan**, Ernest J. Poirier**, and Howard F. Taylor***

ABSTRACT

Data are presented showing the effect of section thickness and chilling on the mechanical properties of sand cast magnesium alloy test plates. The alloys studied were AZ92A and AZ91C. Plate thickness was varied from 1/4 to 1-1/2-in.

The mechanical properties of sand cast AZ92A and AZ91C alloy plates decrease with increasing casting section size. End chilling of the heavier plates improves the mechanical properties of the plates, even at distances well removed from the chill. These data should be useful in the rigging design of high strength magnesium castings. Application of the data should permit production of castings with tensile strengths the order of 50 per cent greater than present minimum specifications. Improvements in yield strength and elongation should also be obtained.

INTRODUCTION

In several recent papers[1,2] techniques for producing high-strength, high-ductility aluminum alloy castings have been described. It was shown that with careful, but commercially feasible practices, aluminum alloy castings could be produced with mechanical properties higher than those obtained by normal foundry procedures. A number of commercial foundries are using these techniques in production of high quality castings.

It is now possible to obtain 356 alloy castings from several sources with minimum mechanical properties of 38,000 psi ultimate tensile strength, 28,000 psi yield strength, and 5 per cent elongation. Normal specifications for this alloy anticipate average mechanical properties in castings as low as 22,500 psi ultimate tensile strength, 20,000 psi yield strength, and 3/4 per cent elongation.

The largest market for castings made by these techniques has been the aircraft and missile fields. In these fields strength-to-weight ratios and casting reliability are vitally important. Since their introduction into these fields, other advantages of high-strength, high-ductility aluminum castings have become apparent. These include improved machinability and dimensional stability. However, aircraft designers still wish to know how parts can be made lighter and still do the job. In this regard, magnesium alloys have potential advantages. It should be possible to produce magnesium castings with a higher strength-to-weight ratios than aluminum. On a simple volume basis (sometimes important in design) magnesium is lighter than other common structural metals. Another parameter of importance in complex missile design is the stiffness-to-weight ratio. Here, magnesium alloys possess an advantage over aluminum or high-strength steel.

The M.I.T. Foundry Laboratory and Instrumentation Laboratory has sponsored and conducted a study to determine if the mechanical properties of magnesium casting alloys can be improved by control of foundry techniques. The study has been divided into two sections, 1) an investigation of the properties obtainable (by careful foundry techniques) in simple plate sections and 2) application of results obtained to the rigging of prototype commercial castings. The first of these studies is presented here.

In this work, the foundry procedures and controls exercised were generally similar to those used in production of high-strength, high-ductility aluminum alloy castings.[1,2] These include control of 1) chemical analysis, 2) melting practice, 3) dissolved gases, 4) gating and risering, and 5) chilling. Alloys studied were AZ92A (9% Al, 2% Zn, 0.15% Mn), and AZ91C (8.7% Al, 0.7% Zn, 0.15% Mn).

PROCEDURE

The test pattern shown in Fig. 1 was employed throughout this phase of the investigation. Foundry controls were held constant. A study was made of the effect of section size and end chilling on the mechanical properties of the test plates. Section size was varied from 1/4 to 1-1/2-in. with the alloys AZ91C and AZ92A. For each alloy, a series of end chilled plates were poured. A similar series of unchilled plates were also poured for comparison. All plates were heat treated. Tensile bars were machined from various locations in the plates, tested, and the data plotted as shown in Fig. 2-5. A metallographic examination of the effect of section size and chills on metal structure was simultaneously carried out. Representative photomicrographs are shown in Fig. 6 and 7.

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Chemical Control and Melting Practice

Melting stock was composed of high-purity virgin material, and high purity remelt stock. AZ92A alloy (aim analysis—9% Al, 2% Zn, 0.15% Mn), and AZ91C (aim analysis—8.7% Al, 0.7% Zn, 0.15% Mn) were formulated. Virgin material used was magnesium pig (99.9%), aluminum pig (99.9%), zinc (99.9%), and aluminum-manganese hardener (75% Al, 25% Mn). Remelt stock consisted of returns from previous heats which had been remelted, pigged, and analyzed.

Melting was conducted in an open-top, gas-fired furnace, using iron crucibles. In the melting practice of both alloys, the high-purity remelt stock was charged first. All elements except zinc were added shortly after meltdown. The zinc was added at 1250 to 1300 F. During melting, a commercial flux covering was maintained on the melt surface to prevent burning. Degassing was accomplished by bubbling chlorine through the melt for 10 min at 1330 to 1380 F.

Grain refinement was obtained by superheating to 1650 F and holding for 15 min. Before pouring, the flux was skimmed from the melt and replaced with a light layer of sulfur-boric acid mixture. Molds were flushed with SO_2 gas immediately before pouring.

Gating, Risering, Molding

The gating system used is illustrated in Fig. 1. The system is a modification of that previously used for aluminum castings[1], and involves a drag-to-cope runner with screen at the parting line. The screen extends over a sizable length of the runner to avoid the possibility of its becoming plugged with dross. A gating ratio of 1:4:3 was employed.

Riser sizes employed for the various plate castings are also listed in Fig. 1. In general, these risers are larger than would ordinarily be necessary. They were chosen to avoid any possibility of property variation due to insufficient feed metal.

Number 80 AFS green sand was used for molding all plates. The sand was inhibited with a 1-1/2-per cent boric acid, 1-1/2-per cent sulfur mixture. In the end-chilled plates, a 15 lb aluminum chill was rammed in the green sand at the plate extremity. The chill was coated with a rosin-talc wash. Previous work[3] has shown that much smaller chills (the order of the weight of the section to be chilled) would have been nearly as effective as the large chill used. The chill weight would ordinarily be reduced in practice.

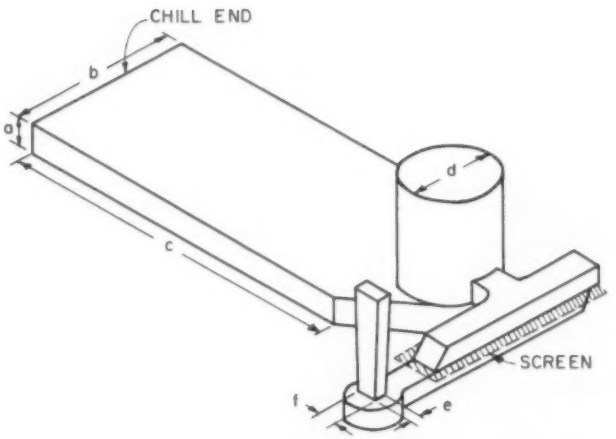

Plate No.	Dimensions a	b	c	d	e	f
(1)	1-1/2	6	18	5	5/8	5/8
(2)	1	6	12	4	5/8	5/8
(3)	3/4	6	9	3	1/2	5/8
(4)	1/2	6	6	2	1/2	1/2
(5)	1/4	6	6	2	1/2	1/2

Gating ratio for all castings, Sprue : Runner : Gate—1:4:3

Fig. 1—Sketch of plate patterns used for chill depth studies.

Heat Treatment

During solution treatment, an SO_2 atmosphere was maintained in the furnace. After solution treatment, all castings were air cooled and held for 24 hr before aging (Table 1).

Testing and Metallographic Examination

Both chilled and unchilled plates in the two alloys were similarly tested. Test bars were cut parallel to the chill face (Fig. 1) at varying distances from the

TABLE 1 — HEAT TREATMENT SCHEDULES

AZ92A Alloy	AZ91C Alloy
Solution Heat Treatment, F	
2 hr at 665	2 hr at 665
6 hr at 765	6 hr at 775
2 hr at 665	2 hr at 665
10 hr at 765	10 hr at 775
Aging Treatment, F	
4 hr at 500	16 hr at 335

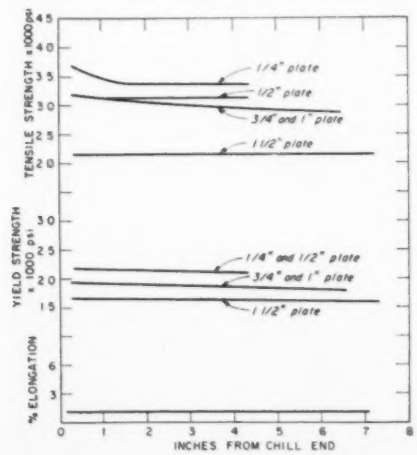

Fig. 2—Summary of mechanical properties of unchilled AZ92A alloy plates.

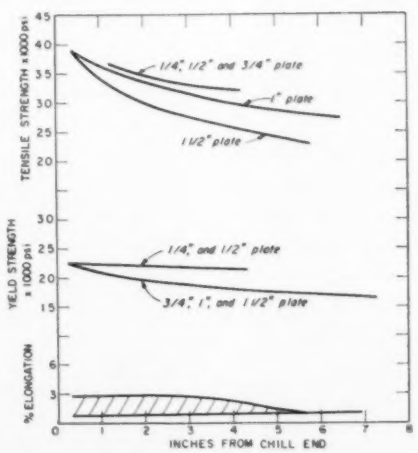
TENSILE STRENGTH x 1000 psi
1/4", 1/2" and 3/4" plate
1" plate
1 1/2" plate
YIELD STRENGTH x 1000 psi
1/4" and 1/2" plate
3/4", 1", and 1 1/2" plate
% ELONGATION
INCHES FROM CHILL END

Fig. 3—Summary of mechanical properties of chilled AZ92A alloy plates.

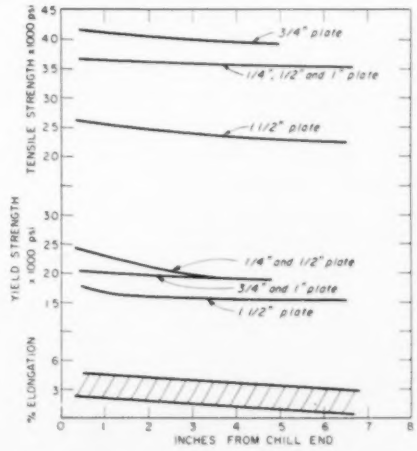

Fig. 4—Summary of mechanical properties of unchilled AZ91C alloy plates.

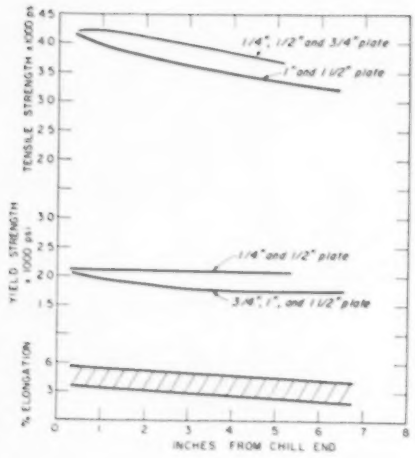
TENSILE STRENGTH x 1000 psi
YIELD STRENGTH x 1000 psi
% ELONGATION
1/4", 1/2" and 3/4" plate
1" and 1 1/2" plate
1/4" and 1/2" plate
3/4", 1", and 1 1/2" plate
INCHES FROM CHILL END

Fig. 3 – Summary of mechanical properties of chilled AZ91C alloy plates.

chill end. In plotting mechanical properties vs. distance from the chill face, the distance from the chill face to the center of the test bar cross section was used.

Test bars of 0.505 diameter and 2 in. gauge length were used for all plates thicker than 3/4-in. For the thinner plates, 1/4-in. square test bars, 2 in. gauge length—were employed. Tensile strength, yield strength, and per cent elongation, were measured. Yield strength was obtained by the 0.2 per cent offset method.

All plates were x-rayed to MIL-1-6865A specification. Casting soundness equaled or exceeded A.S.T.M. Reference Radiograph 1.1, No. 1, indicating all plates were free of visible x-ray porosity.

Metallographic specimens from all AZ91C alloy plate castings were taken from the test bars closest to the chill end, and 2-1/2-in. away from the chill end. The specimens were polished and etched to determine grain size, massive compound rating, and per cent precipitate according to published metallographic techniques.[2]

RESULTS

Chemical analyses of all heats poured are listed in the Appendix, Table A. The 1-1/2-in. plates of AZ91C alloy were cast from Heat A, while remaining AZ91C plates were cast from Heat B. All AZ92A plates were cast from Heat C. Two cast-to-size test bars were poured with each heat, and tested after heat treatment. Mechanical properties of these test bars are listed in the appendix, Table B.

The tensile data obtained from the plate castings are tabulated in the remaining appendix tables. They are also plotted in Fig. 2-5 as mechanical properties vs. distance from the chill end.

The mechanical properties of the unchilled AZ92A plates are plotted in Fig. 2. The graph illustrates the recognized effect of section size on mechanical properties of nonferrous sand castings. As the section thickness decreases, mechanical properties generally improve. Properties in the thickest plate (1-1/2-in.) average about 21,000; 16,000; 1,*. Those in the thinnest plate (1/4-in.) are about 35,000; 21,000; 1. Mechanical properties along the length of each plate are nearly uniform.

*The shorthand 21,000; 16,000; 1 is used to denote 21,000 psi ultimate tensile strength, 16,000 psi yield strength, 1 per cent elongation.

When end chills are added to the sand cast AZ92A plates, a property improvement results as shown in Fig. 3. Bars nearest the chill average approximately 38,000; 22,500; 1-3. Comparison of Fig. 2 and 3 indicates that this is a relatively small improvement in the case of the thinner plates. However, it is a substantial improvement in properties of the thicker plates.

The tensile strength of the bar at the extremity of the 1-1/2-in. plate is nearly doubled by chilling. Yield strength and elongation at the plate extremity are also improved somewhat by chilling. The improvement is less marked than is the case with the tensile strength. The improvement in elongation to be obtained by chilling was found real, but not consistent. Elongations of the unchilled AZ92A plates were found close to 1 per cent, while elongations of the chilled plates (near the chill) varied from one to three per cent.

Increasing the distance from the chill generally decreased the mechanical properties of chilled AZ92A plates (Fig. 3). The decrease is most marked in the case of the tensile strength. Properties of the chilled plates (especially the heavier sections) are, none-theless, superior to the properties of the unchilled plates (Fig. 3) at greater distances from the chill. In the case of the heaviest plate, the beneficial effect of the chill is felt at distances up to about 5 in. away from the chill. In thinner plates, the distance is somewhat less.

Figures 4 and 5 illustrate similar data for AZ91C alloy. The mechanical properties of the unchilled, sand-cast plates decrease with increasing section size (except for the 3/4-in. plate, Fig. 4). Mechanical properties of the thinner plates (1/4-in., 1/2-in.) average about 36,000; 21,000; 2-4. Properties of the 1-1/2-in. plate are approximately 24,000; 15,500; 2.

The effect of chilling AZ91C plates (Fig. 5) is similar to that of chilling AZ92A alloy plates. Mechanical properties of bars nearest the chill all average about 42,000; 22,000; 4-6. These properties are an improvement over those of the heavier, unchilled plates, but are not a great deal higher than those of the thinner unchilled plates.

Mechanical properties of the chilled plates decrease with increasing distance from the chill. However, the beneficial effect of chilling is obtained at distances well removed from the chill. In the 1-1/2-in. plate, this distance is apparently greater than 6 in.

TABLE 2 – MICROSTRUCTURE RATINGS OF AZ91C ALLOY PLATES

Plate Size, in.	1/4-in. from chill end		2-1/2-in. from chill end	
	Grain Size, in.	Massive Comp. Rating	Grain Size, in.	Massive Comp. Rating
		Unchilled		
1/4	0.003	1	0.003	1
1/2	0.003	3	0.003	2
3/4	0.004	3	0.004	4
1	0.004	5	0.003	6
1-1/2	0.008	7	0.008	7
		Chilled		
1/4	0.002	0	0.003	0
1/2	0.002	0	0.003	1
3/4	0.002	0	0.003	3
1	0.002	0	0.004	4
1-1/2	0.002	0	0.006	4

A preliminary study has been undertaken to determine the mechanism whereby chills improve the mechanical properties of cast magnesium alloys. This study has been limited entirely to microstructural examination of AZ91C alloy. Samples for this investigation were cut from the shoulders of the tensile test specimens described above. Samples were cut from each of the AZ91C plates at 1) the location nearest the chill (0.3-in.), and 2) the location approximately 2-1/2-in. from the chill. Samples were polished and etched to determine grain size and compound rating. Results of this investigation are tabulated in Table 2. Typical microstructures from the 1-1/2-in. plates are shown in Fig. 6 and 7.

Table 2 illustrates that in the 1/4-in. unchilled plate, a relatively fine grain size (0.003-in. diameter), and low compound rating (rating 1)* was obtained. As the thickness of the unchilled plate increases, grain size and massive compound rating also increase. In the 1-1/2-in. plate the grain size is 0.008 in. diameter, and compound rating is 7.

Chilling reduces the grain size of all plates to 0.002 in. diameter, and the compound rating to 0 (near the chill). These are not much smaller than the grain size and compound rating of the unchilled 1/4-in. plates. However, they are substantially smaller than those of the unchilled heavy section plates. At a distance of 2-1/2-in. away from the chill, the chill results in a substantial reduction of grain size and compound rating in the heavier plates.

In Fig. 6, typical grain sizes of the chilled and unchilled 1-1/2-in. plates are shown. Figure 7 shows the massive compound in these plates.

*Rating of 0 indicates the massive Mg-Al-Zn compound is completely solutionized. Rating of 10 indicates amount of compound obtained in the nonheat-treated condition.

Fig. 6—Photomicrographs showing effect of chilling on the grain size of sand cast 1-1/2-in. AZ91C plates. Picral acid etch. 100 X.

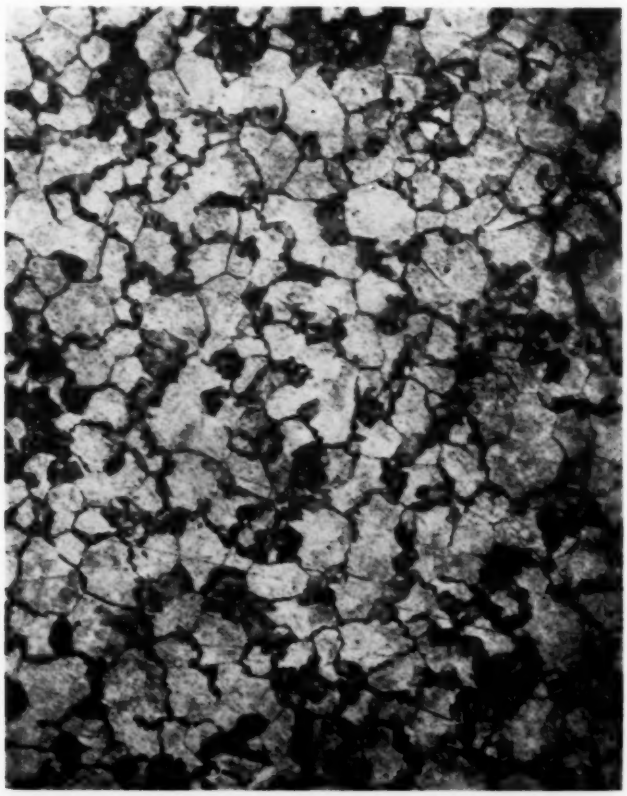

Fig. 6a.- Grain size 0.002 in. diam., 0.3 in. from chill.

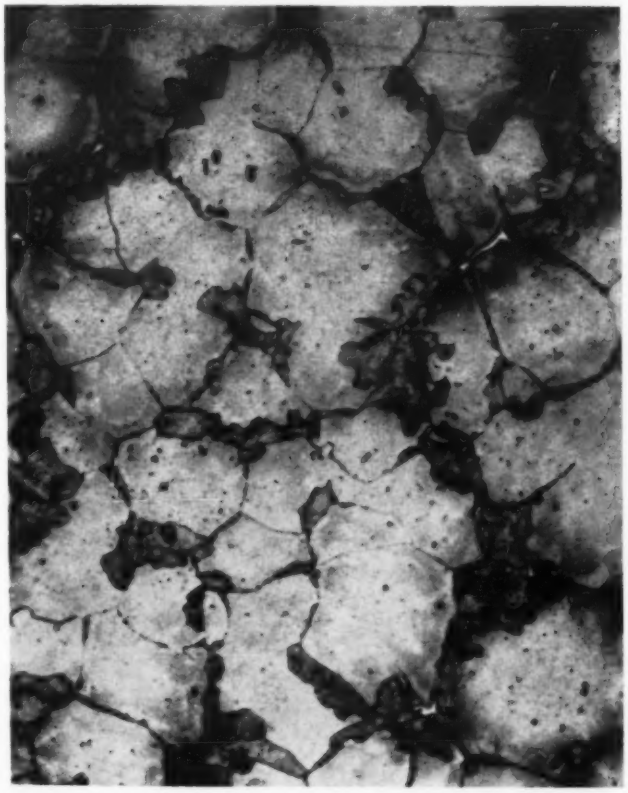

Fig. 6b—Grain size 0.006 in. diam., 2-1/2-in. from chill.

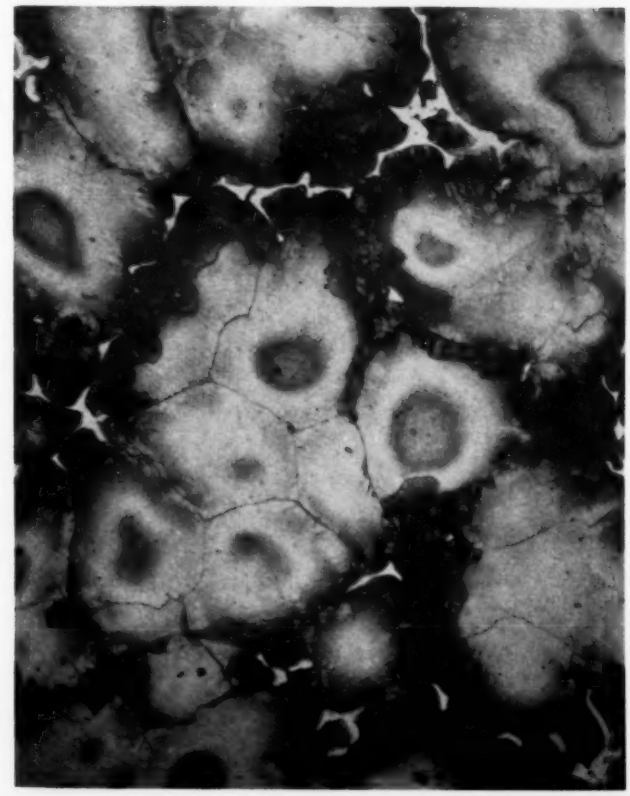

Fig. 6c—Grain size 0.008 in. diam., 0.3 in. from unchilled end.

DISCUSSION

Present minimum mechanical property specifications[5] for AZ92A alloy cast-to-size tensile bars are 34,000 psi ultimate tensile strength, and 18,000 psi yield strength (no elongation requirement). These property minimums are not often met in the actual casting, and the specification allows for this. Mechanical properties of test bars cut from the casting are permitted to average a minimum of 25,500 psi ultimate tensile strength, and 16,000 psi yield strength. Individual bars may be as low as 17,000 psi ultimate tensile, and 13,500 yield. (Table 3).

These data indicate that AZ92A sand-cast sections of less than about 1/2-in. thickness may possess mechanical properties nearly as high as those of the cast-to-size test bar. Properties of heavier AZ92A plates, however, (or presumably properties at junctions, bosses or other hot spots) fall below the minimums of the cast-to-size test bar. They approach the minimum values shown in Table 3 for individual bars cut from castings. The data further show that chills may be used to improve the mechanical properties of heavy sections. The maximum properties in AZ92A plates which were obtained by chilling averaged about 40,000; 22,000; 2-4 (near the chill). At distances away

TABLE 3 – SOME MECHANICAL PROPERTIES OF CAST MAGNESIUM ALLOY AZ92A

Test Bars	T.S. psi	Y.S. psi	% Elong. in-2 in.
0.505 Cast to Size Test Bar (Typical)[a]	40,000	22,000	3
0.505 Cast to Size Test Bar (Min)[b]	34,000	18,000	N.R.[*]
Test Bars Cut from Casting (Ave)[c]	25,500	16,000	N.R.
Test Bars Cut from Castings (Min)[c]	17,000	13,500	N.R.
Test Bars taken from Chilled Area of Sand Casting, from metal of controlled chemistry, gas and heat treatment (typical)	40,000	22,000	3

[*] N.R –Not required.
[a] R. A. Townsend, *Metals Handbook*, 1948, p. 1018, Published by A.S.M., Cleveland, Ohio.
[b] QQ-M-56(a), September 3, 1957.
[c] QQ-M-56(a), These properties are representative of the weakest areas in any type casting for magnesium alloy AZ92A, adjacent to sprues and risers.

Fig. 7a–Compound rating-O, 0.3 in. from chill.

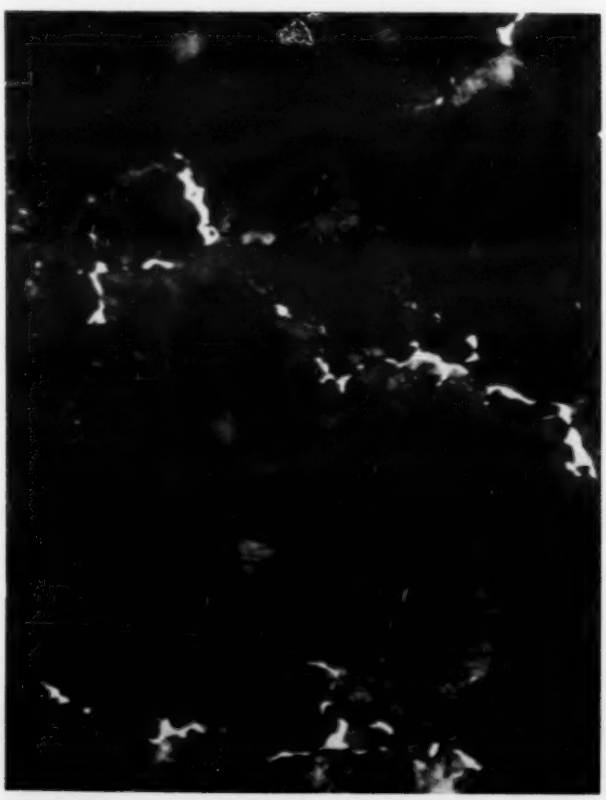

Fig. 7b–Compound rating–4, 2-1/2-in. from chill.

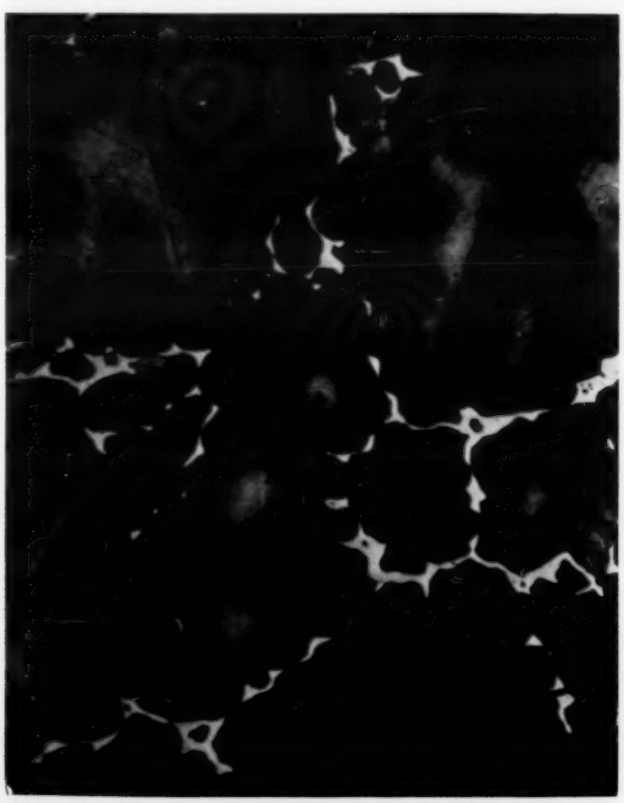

Fig. 7c–Compound rating–7, 0.3 in. from unchilled end.

Fig. 7–Photomicrographs showing effect of chilling on the massive compound of sand cast 1-1/2-in. AZ91C plates. Glacial acetic acid etch. 100X.

from the chill, the properties decreased. Even at considerable distances away the properties remained substantially above those of the unchilled plates.

Table 4 lists similar mechanical property data for AZ91C alloy. Minimum mechanical properties in the cast-to-size test bar of 34,000; 16,000; 3 are required by specification. However, the properties in the casting may average as low as 25,500; 14,500; 3/4. Individual bars from the casting with properties exceeding 17,000; 12,000; 0 are acceptable as long as the average (of bars tested) meets the above level. Figures 4 and 5 indicate that thin-section plates may possess properties equivalent to those of the cast-to-size test bar minimums. Properties of heavier sections are considerably lower.

Chilling of AZ91C alloy plates results in improvement of the properties of the heavier section plates. The improvement with AZ92A is felt at distances well removed from the chill. Maximum properties (obtained near a chill) were approximately 42,000; 22,000; 4-6 for all plates.

A limited investigation of the mechanism whereby chilling improves mechanical properties of cast magnesium alloys has indicated two variables are important. These are 1) grain size and, 2) compound rating. Both coarse grain size and high-compound ratings are expected to result in low mechanical properties.[6] In the unchilled 1/4-in. plate a relatively fine grain size and low compound rating was observed (Table 2). As the plate section was increased, the grain size and compound rating also increased.

Chilling reduced the grain size and compound ratings of all plates (near the chill) to levels lower than those of the 1/4-in. plate. In the thinnest plates, the chill effect of the sand is adequate to produce a fine structure essentially free of coarse compound. Chilling is essential to achieve this in the heavier plates, at least with the heat treatment practice employed. Investigation of possible effects of chilling on microporosity is anticipated but has not yet been undertaken.

Rigging Design of High Strength Magnesium Castings

The data presented are intended to serve as a guide for use in chill placement on production-type castings when uniformly high mechanical properties are desired. It should be possible to effectively cut intricate castings into a series of plates by alternate risering and chilling. Mechanical properties in the casting should be obtained equivalent to those obtained in chilled plates.

Mechanical properties (Fig. 4) of 25,000 psi ultimate tensile strength, 15,000 psi yield strength, and 2-4 per cent elongation would be expected in an unchilled AZ91C casting in a 1-1/2-in. thick section. By chilling and risering this section so the maximum distance between chill and riser is 2 in., properties of about 37,000; 18,000; 3-5 would be expected. Such a chill-riser distance should be feasible in production. The properties obtained (37,000; 18,000; 3-5) are an improvement in tensile strength of 46 per cent, in yield strength of 2 per cent, and a four-fold increase in elongation over present minimum properties of 25,500; 14,500; 3/4 (Table 4).

TABLE 4 — SOME MECHANICAL PROPERTIES OF CAST MAGNESIUM ALLOY AZ91C

Test Bars	T.S. psi	Y.S. psi	% Elong. in 2 in.
0.505 Cast to Size Test Bar (Typical)[a]	40,000	19,000	4
0.505 Cast to Size Test Bar (Min)[b]	34,000	16,000	3
Test Bars Cut from Casting (Ave)[c]	25,500	14,500	3/4
Test Bars Cut from Casting (Min)[c]	17,000	12,000	0
Test Bars taken from Chilled Area of Sand Casting, from metal of controlled chemistry, gas and heat treatment (typical)	41,000	20,000	4

[a] A.S.M. Commitee on Magnesium, "Magnesium and Magnesium Alloys", *Metal Progress, V. 66, No. 1A*, July 15, 1954, p. 73.
[b] QQ-M-56(a), September 3, 1957.
[c] QQ-M-56(a), These properties are representative of the weakest areas in any type casting for magnesium alloy AZ91C, adjacent to sprues and risers.

The data obtained indicate that chilling of casting sections of less than 1/4 to 1/2-in. should result in little property improvement, unless bosses or other hot spots act to slow the cooling rate. A degree of caution is necessary in the application of the data, as the numerical values obtained are dependent on variables. These may vary from heat to heat or casting to casting. Some of these variables are chemistry, heat treatment, metal gas content, chill wash, thickness, and chill-contact area. However, the qualitative use of the data on production type castings appears justified.

SUMMARY

Data showing the effect of section size and end chilling on the mechanical properties of AZ91C and AZ92A alloy plates have been presented. As section size was increased, mechanical properties of plates of both alloys decreased.

End chilling improved the mechanical properties of the heavy section plates (over 1/2-in.), but had little effect on the properties of the thinner section plates. Apparently, the chill effect of the sand alone was sufficient to produce high mechanical properties in the thinner plates.

The data presented is intended for use in the rigging of high-strength, magnesium-alloy castings. By judicious use of chills on heavy sections of castings, and careful foundry practice, properties above present minimum values may be consistently obtained in the casting regardless of casting section size.

ACKNOWLEDGEMENT

The authors wish to express their appreciation to the Instrumentation Laboratory, M.I.T., for support of this work through Air Force Ballistic Missile Division, Contract AF 04(645-9). Grateful acknowledgement is also due to a number of staff members of the Dow Chemical Company, Magnesium Department, for their advice and support in many phases of the magnesium research program at M.I.T. The many technical bulletins published by Dow Chemical Company on magnesium foundry practice have also been a valuable source of technical information.

REFERENCES

1. Flemings, M. C., Norton, P. J., and Taylor, H. F., "Performance of Chills on High Strength–High Ductility Sand Castings of Various Section Thicknesses", TRANSACTIONS AFS *Vol.* 65, 1957, p. 259.
1. Flemings, M. C., Norton, P. J., and Taylor, H. F., "Perform-

Design of a Typical High Strength, High Ductility Aluminum Alloy Casting", TRANSACTIONS AFS, *Vol.* 65, p. 550.
3. Foundry Section, Metals Processing Division, Department of Metallurgy, M.I.T., Unpublished work.
4. George, P. F., "A Numerical Rating Method for the Routine Metallographic Examination of Commercial Magnesium Alloys", Submitted American Society for Testing Materials, June 26–30, 1944.
5. Federal Specification QQ-M-56 (a), September 3, 1957, "Magnesium Alloy, Sand Castings".
6. Brace, A. W., and Allen, F. A., *Magnesium Casting Technology*, (1957) Reinhold, New York, N. Y., p. 36.

APPENDIX

TABLE A – CHEMICAL ANALYSES OF EXPERIMENTAL HEATS

Heat	Alloy	Al	Zn	Mn	Cu	Si
A	AZ91C	8.50	0.74	0.16	N.D.	T
B	AZ91C	8.85	0.725	0.15	T	T
C	AZ92A	9.21	2.07	0.14	T	0.012

T – Trace
N.D. – Not Detected

TABLE B – MECHANICAL PROPERTIES OF CAST-TO-SIZE TEST BARS FROM EXPERIMENTAL HEATS

Heat	Ultimate Tensile Strength, psi	Yield Strength, psi	Percent Elongation, in 2-in.
A	39,500	20,750	3
	40,400	21,250	4
B	36,900	19,400	3
	37,300	18,100	3
C	36,600	22,500	1
	37,500	23,500	1

TABLE C – MECHANICAL PROPERTIES OF CHILLED PLATES – AZ91C ALLOY – HEAT A

Plate Size	In. from Chill	Percent El. in 2-in.	Yield St. psi	U.T.S. psi
1-1/2	0.4	4-1/2	21,000	40,600
	1.1	3	20,500	38,100
	1.9	5	18,500	38,300
	2.6	4-1/2	17,500	36,900
	3.4	5	17,000	36,000
	4.1	4	17,300	36,000
	4.9	3	17,800	32,700
	6.4	1-1/2	17,800	30,900

TABLE D – MECHANICAL PROPERTIES OF CHILLED PLATES – AZ91C ALLOY – HEAT B

Plate Size	In. from Chill	Percent El. in 2-in.	Yield St. psi	U.T.S. psi
1	0.4	4	18,500	42,000
	1.1	3-1/2	20,100	42,000
	2.6	3	20,500	36,600
	3.4	3	18,500	35,200
	4.9	3	18,800	34,900
	6.4	3	17,800	33,200
3/4	0.4	5	19,500	41,800
	1.1	6	19,000	42,300
	1.9	6	17,300	41,100
	2.6	5-1/2	18,300	39,200
	3.4	4	17,800	38,300
	4.1	4-1/2	17,500	37,800
	4.9	4	17,000	37,500
1/2	0.25	3	21,200	39,200
	0.75	6	25,000	42,700
	1.25	3-1/2	24,100	38,800
	2.25	3-1/2	20,800	40,500
	3.25	3	21,100	37,400
	4.25	2	19,500	36,800
1/4	0.25	4	21,900	41,500
	0.75	4	20,600	40,800
	1.25	4	22,400	41,300
	2.25	3-1/2	21,100	40,000
	3.25	1	21,600	35,200
	3.75	4	21,800	39,100

TABLE E – MECHANICAL PROPERTIES OF CHILLED PLATES – AZ92A ALLOY – HEAT C

Plate Size	In. from Chill	Percent El. in 2-in.	Yield St. psi	U.T.S. psi
1-1/2	0.4	2	21,500	38,600
	1.1	3	19,500	35,400
	1.9	1	18,500	30,800
	3.4	1	17,000	26,400
	4.9	1	15,300	24,200
	5.6	1	17,500	23,900
	7.1	1	16,300	22,900
1	0.4	2	21,600	37,500
	1.1	1	19,800	35,000
	1.9	1	18,800	33,800
	3.4	2	18,300	30,100
	4.9	1	16,100	28,400
	6.4	1	17,500	27,800
3/4	0.4	3	21,500	40,300
	1.1	2	21,500	37,500
	1.9	1-1/2	19,300	34,700
	2.6	3	19,800	37,400
	3.4	1	19,500	32,200
	4.1	2	18,300	32,700
1/2	0.25	1-1/2	22,500	36,200
	0.75	1-1/2	22,500	37,000
	1.25	1	22,100	33,000
	2.25	1/2	21,600	33,000
	3.25	1-1/2	21,200	31,400
	4.25	2	21,600	32,400
1/4	0.25	1/2	22,100	34,800
	0.75	1/2	22,600	34,400
	1.25	1/2	20,900	31,700
	2.25	1	21,700	33,600
	3.25	1/2	21,800	32,500
	3.75	1/2	20,700	33,200

TABLE F – MECHANICAL PROPERTIES OF UNCHILLED PLATES – AZ91C ALLOY – HEAT A

Plate Size	In. from End	Percent El. in 2-in.	Yield St. psi	U.S.T. psi
1-1/2	0.4	2	17,500	26,000
	1.1	2	16,250	25,500
	1.9	1	15,600	24,400
	3.4	2	15,500	23,400
	4.9	1	15,800	22,700
	6.4	1	15,300	22,500

TABLE G – MECHANICAL PROPERTIES OF UNCHILLED PLATES – AZ91C ALLOY – HEAT B

Plate Size	In. from End	Percent El. in 2-in.	Yield St. psi	U.S.T. psi
1	0.4	3	21,000	35,500
	1.1	2-1/2	19,700	35,300
	2.6	2	20,000	35,700
	3.4	2	20,000	34,900
	4.9	2-1/2	20,000	36,400
	6.4	3	19,300	37,400
3/4	0.4	3	20,000	39,000
	1.1	5	19,200	41,500
	1.9	4-1/2	19,500	41,000
	2.6	4	19,500	41,200
	3.4	3	19,000	38,300
	4.1	4	17,500	39,700
	4.9	6	18,500	40,100
1/2	0.25	2	23,700	36,800
	0.75	2-1/2	23,800	38,200
	1.25	4	23,200	42,300
	2.25	3	22,600	37,300
	3.25	2	21,200	36,800
	4.25	5	19,100	37,900
1/4	0.25	2	21,200	38,300
	0.75	1	21,600	33,800
	1.25	3	23,300	37,900
	2.25	2	21,000	36,600
	3.25	2	21,200	34,700
	3.75	4	19,900	37,000

TABLE H – MECHANICAL PROPERTIES OF UNCHILLED PLATES – AZ92A ALLOY – HEAT C

Plate Size	In. from End	Percent El. in 2-in.	Yield St. psi	U.S.T. psi
1-1/2	0.4	1	16,500	21,600
	1.1	1	16,900	21,700
	1.9	1	16,000	20,200
	3.4	1	16,000	20,900
	4.9	1	16,500	21,500
	6.4	1	16,300	20,700
	7.1	1	16,300	22,400
1	0.4	1/2	19,500	31,400
	1.1	1-1/2	19,600	32,600
	1.9	1	19,300	31,200
	3.4	1	18,300	27,700
	4.9	1	18,300	29,500
	6.4	1-1/2	17,500	29,200
3/4	0.4	1-1/2	18,800	31,300
	1.1	1	19,000	30,500
	1.9	1	19,000	29,900
	2.6	1	18,500	29,000
	3.4	1	18,700	30,100
	4.1	1	18,500	29,600
1/2	0.25	1/2	24,200	31,500
	0.75	1	23,200	32,000
	1.25	1/2	21,700	30,600
	2.25	1/2	21,700	32,800
	3.25	1	23,400	31,800
	4.25	1	21,100	32,000
1/4	0.25	1-1/2	20,900	36,600
	0.75	1	21,800	33,200
	1.25	1	21,800	34,400
	2.25	1/2	19,800	32,400
	2.75	1	20,500	33,600
	3.75	1-1/2	20,700	35,000
	4.25	1	21,000	34,300

SOME FACTORS AFFECTING THE TOUGHNESS OF MILD STEEL CASTINGS

By
Herbert H. Fairfield* and John A. Ortiz**

ABSTRACT

The influence of sulfur, carbon and hydrogen on steel ductility is discussed, as well as the effects of various steelmaking operations during melting. Reduction of area is used as the measure of toughness. All reduction of area values quoted are from separately cast test bars which have been normalized from 1650 F and drawn for 8 hr at 1250 F.

INTRODUCTION

This paper refers to mild steel made in the electric-arc furnace. The majority of steel castings are made to conform with the A. S. T. M. Specification A-216-53T which requires tensile test bars to meet the requirements in Table 1.

Reduction of area is used here as the measure of steel quality. The discussion will be confined to those factors which affect reduction of area (RA).

All of the RA values quoted are from separately cast test bars which were normalized at 1650 F, and drawn for 8 hr at 1250 F.

ACKNOWLEDGMENT

This paper was prepared under the direction of Mr. George B. Emmett, Works Manager, Los Angeles Steel Casting Co. His advice and support are gratefully acknowledged.

TENSILE STRENGTH

When using RA as an index of toughness, it is necessary to correct for the effect of tensile strength. Table 2 shows the approximate relationship between RA and ultimate tensile strength of plain carbon steel castings, as observed in the authors' company.

All RA values in this paper are corrected to 75,000 psi. A test bar with a tensile of 84,000 psi, and an RA of 45 per cent would be corrected as follows:

1—Normal RA for 84,000 psi is 48 per cent for steel made in an acid furnace.
2—Test bar is 3 per cent lower than normal.
3—Normal RA for 75,000 psi is 52.5 per cent.
4—Corrected RA is 52.5 minus 3 per cent, or 49.5 per cent.

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Another measure of steel quality mentioned in the literature is the p value.

$$p = \frac{6000 \text{ RA plus tensile strength in psi}}{5000}$$

EFFECT OF SULFUR ON RA

Results of a survey of test bar from both acid and basic steel shows the relationship between sulfur and RA shown in Table 3. The optimum range for sulfur appears to be 0.015 to 0.030 per cent. Sulfur forms brittle grain boundary inclusions above 0.03 per cent.

It has been observed that when sulfur is less than 0.015 per cent erratic test results occur. The reason is that long periods of time under a reducing slag are required to lower the sulfur content in the steel. This condition exposes the metal to the possibility of hydrogen absorption. Hydrogen is then the cause of lowered ductility in the metal.

ACID OR BASIC STEEL

If scrap is available which contains less than 0.025 per cent sulfur, high-ductility steel can be made in an acid-lined furnace. When the sulfur content of scrap is over 0.03 per cent, if highest ductility is required, it is necessary to use the basic furnace for melting.

TABLE 1 – TENSILE TEST BAR REQUIREMENTS

Tensile strength	70,000 psi min.
Yield strength	36,000 psi min.
Elongation	22 per cent min.
Reduction of Area	35 per cent min.

TABLE 2 – EFFECT OF TENSILE STRENGTH ON REDUCTION OF AREA – CARBON STEEL

Tensile Strength psi	REDUCTION OF AREA		
	Acid Furnace 0.20–0.30% C	Basic Furnace 0.20–0.30% C	Acid Furnace 0.35–0.45% C
70,000	55	58	
72,000	54	57	
74,000	53	56	
76,000	52	55	
78,000	51	54	46
80,000	50	53	45
82,000	49	52	44
84,000	48	51	43
86,000	47	50	42

CARBON

Statistical analysis of tensile results are shown in Table 2. At 0.40 per cent carbon, RA averaged 5 per cent lower than when carbon was 0.25 per cent. For highest ductility in carbon steel, a maximum of 0.33 per cent carbon is recommended.

HYDROGEN

The effect of hydrogen upon reduction of area is shown in Fig. 1. In the data presented only four ppm of hydrogen lowered the RA to 34 per cent. It is assumed, therefore, that hydrogen is a major cause of low ductility.

Germain[1] states that the chief source of hydrogen in melting is the breaking down of water vapor during meltdown. Arness[2] points out that when the oxidation phase is completed and the bath killed (de-oxidized) hydrogen absorption starts. It is also known that wet ladles will introduce hydrogen into the metal.

Sims[3] has demonstrated the correlation between atmospheric humidity and the hydrogen content of steel. Since the metal bath is so vulnerable to the detrimental effects of the atmosphere, it would seem desirable to control the furnace atmosphere. In one instance cupola air supply has been brought under humidity control, and it is claimed that iron quality was improved. Post[4] reports favorable results from introducing dry nitrogen into the electric furnace to reduce humidity.

The danger of hydrogen pick up is increased by the addition of smoke control equipment to the furnace. The strong draft from dust collecting devices makes more air pass through the furnace. On some metals sensitive to hydrogen (stainless steel), pinholes can be eliminated by shutting off the smoke collecting system.

A rapid test for hydrogen in steel would be helpful to the steel melter. Peifer[5] has shown that progress is being made in developing such a test. Lacking any information on the hydrogen content of the steel bath after it is melted down, the only safe conclusion to make is that it contains an excessive amount of hydrogen. Hydrogen removal is accomplished by a boil.

TABLE 3 – EFFECT OF SULFUR ON REDUCTION OF AREA

Sulfur Range %	Reduction of Area Corrected to 75,000 psi Median Value, %
0.010–0.014	53.6
0.015–0.019	56.5
0.020–0.024	55.5
0.025–0.029	55.2
0.030–0.034	54.0
0.035–0.039	52.0
0.040–0.044	50.0
0.050–0.059	42.0
0.060–0.069	36.0

THE BOIL

The boil phase of steelmaking is initiated by adding carbon to the bath along with iron ore or oxygen. Carbon monoxide that is formed bubbles up through the metal. The boil has several beneficial effects, 1) it causes a uniform distribution of temperature and composition, 2) it flushes out dissolved hydrogen and nitrogen, 3) it probably aids in removing slag, dirt, and nonmetallic inclusions.

One satisfactory procedure for electric furnace melting is to add ore with the charge, raise the carbon to 0.50 per cent, and oxidize until carbon is reduced to 0.20 per cent or less. This will require about 3 per cent ore for basic, and 6 per cent ore for acid furnaces. Another method is to melt down high in carbon and add enough ore or oxygen to get the boil started.

The effect of the boil on hydrogen content cannot be measured directly during melting. However, there are several useful measures that have proven correlated to the toughness of the finished test bar. Faist and Wyman[6] showed that the rate of carbon drop was related to metal quality. When carbon was reduced at the rate of 0.03 per cent per min, high ductility was obtained.

A manganese analysis at the end of the boil is also a useful index of optimum boil conditions. Figure 2 shows that basic steel heats have the highest RA when oxidized down to about 0.12 per cent manganese.

The practise at the writer's foundry is to melt down high in carbon, send a carbon test to the laboratory, and send another test at the end of the boil. Figure 3

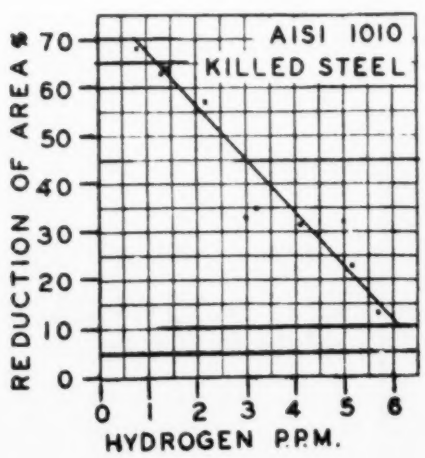

Fig. 1 – Effect of hydrogen upon reduction of area.

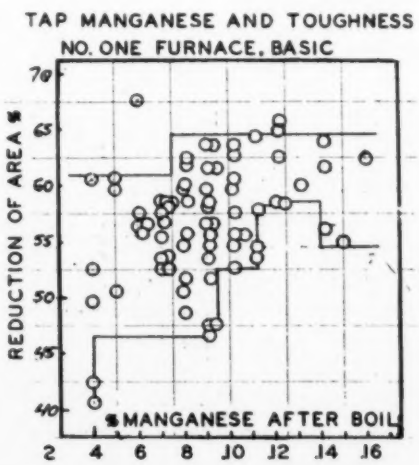

Fig. 2. – Tap manganese and toughness of basic steel.

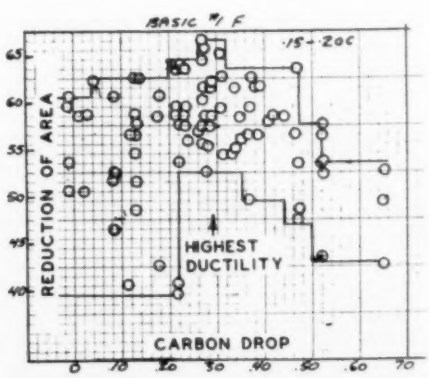

Fig. 3 – Carbon drop and reduction of area, basic steel.

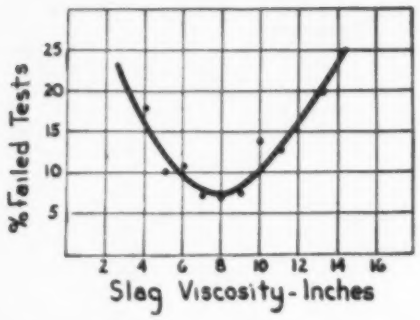

Fig. 4 — Effect of acid slag viscosity on metal quality.

shows the carbon drop obtained from these tests plotted together with the final RA of the test bar.

A carbon drop of 0.30 per cent coincided with maximum ductility. No further improvement was obtained by reducing more than 30 points of carbon during the boil.

By means of carbon and manganese tests, the boil can be measured and boil characteristics can be correlated to test bar results.

The nature of the final slag has an effect upon the quality of test bars produced. Dr. Sims[7] states that the most important function of a slag seems to be to serve as a reservoir for oxygen during the carbon boil. Slag will hold an unlimited amount of oxygen, and will continue to oxidize the steel unless the slag itself is deoxidized. The FeO content of the slag is used as a measure of its oxidizing power. Results may be reported as Fe or FeO. 1.295 grams of FeO contain 1.0 gram of Fe.

Carter[8] reports that both oxidizing and reducing slag extremes proved detrimental to quality. This statement is corroborated by many writers.

ACID PRACTICE

Johnson[9] showed that the best test bars were obtained with a final slag fluidity of 8 in., using the Herty[10] viscosimeter. Juppenlatz[11] reported relationships between slag viscosity and composition.

Figure 4 shows the relationship between slag and metal quality as found by Johnson and McDonough. In Fig. 5, Faist and Wyman indicate that maximum ductility coincided with a final slag containing 10 to 14 per cent FeO.

The writers' findings on tapping slag in acid practice, and its effect upon RA, are shown in Figs. 6 and 7. Heats for large castings were tapped at a temperature of about 2950 F. The highest ductility in these floor heats coincided with a green slag containing about 5 per cent Fe.

Heats for small castings were tapped at about 3150 F. Figure 7 indicates that these hot "bench" heats had the highest ductility when the final slag contained about 10 per cent Fe (black slag).

The optimum slag condition is dependent upon tapping temperature. Further work is needed to clarify this relationship.

BASIC PRACTICE

Statistical analysis of test results in the writers' plant indicate that the optimum lime content for a tapping slag was 35 per cent. Heats tapped at 2950 F showed the highest RA when the Fe content of the slag was 3 per cent to 9 per cent. Heats tapped at 3150 F had the highest toughness when the tapping slag contained 5 per cent to 10 per cent Fe.

As Fig. 1 shows, a slight amount of hydrogen can cause low RA. The presence of dissolved FeO in the metal is presumed to prevent the absorption of hydrogen. A simple test for FeO in the metal can be made by dipping out a sample, and pouring it into an iron mold. Results are shown in Fig. 8. If the metal contains FeO, it will give off a shower of sparks, as shown on the right hand side of Fig. 8. The solidifying metal will mushroom. The experience of the writers has been that for highest quality steel, the bath should be kept wild or oxidized until tapped into the ladle.

When slag and temperature have been adjusted, and bath composition is known the heat is ready to be tapped. No benefit will be obtained from holding the heat in the furnace beyond this point. "The reducing period, save for the instances where it is desirable to recover oxidized alloys from the slag, performs no useful function in steelmaking", M. V. Healey reported.[16]

Where it is necessary to recover alloys from the slag, a reaction which would require 45 min in the furnace can be effected in a few sec by tapping slag and metal together in the ladle. Merrill and Vincent[12] described heats of alloy steel in which the slag contained 6 per cent chromium. By first reducing the slag, and then tapping slag and metal together, nearly all of the chromium was recovered in less than one min.

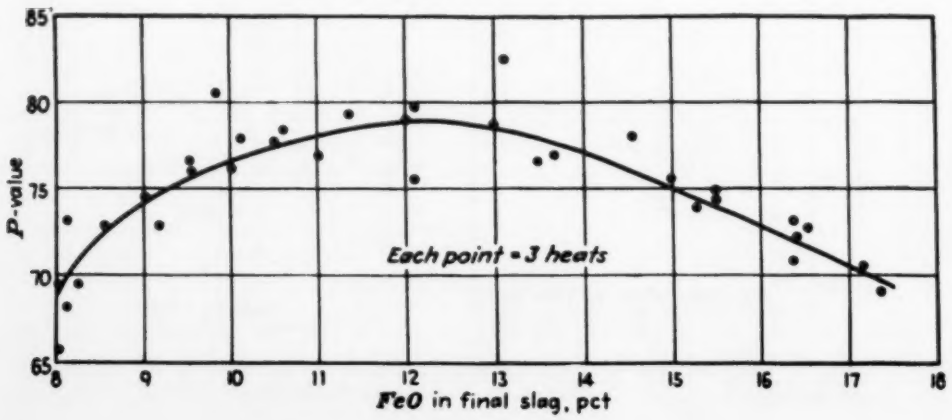

Fig. 5 — Effect of FeO content of acid slag on metal quality.

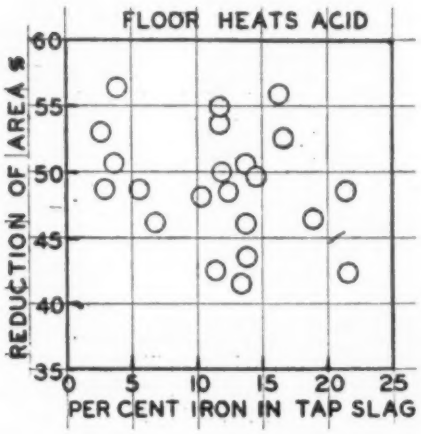

Fig. 6 — Iron in tapping slag and RA heats tapped at 2950 F. (Left)

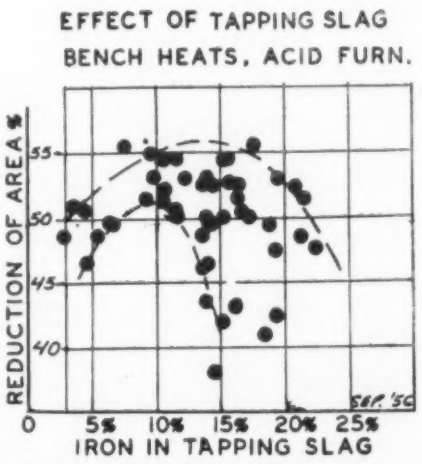

Fig. 7 — Iron in tapping slag and RA heats tapped at 2150 F. (Right)

The Perrin process[13] demonstrates the speed of slag-metal reactions in the ladle. In this process, metal from the acid furnace is poured into a ladle containing slag. Within 45 sec sulfur is reduced from 0.05 per cent to 0.015 per cent.

The above instances demonstrate that slag-metal reactions take place rapidly in the ladle. The operator can prevent or cause slag-metal reactions by his control over the tapping operation.

Before tapping, the temperature of the bath must be raised above 2960 F. This insures that the metal is fluid enough to react with deoxidizers and to enable entrapped oxides to float to the top of the ladle.

One ton of steel can be de-oxidized with 2 lb of aluminum. One ton of slag could easily require 100 lb of aluminum for de-oxidation. Therefore, if the aluminum comes into contact with the slag it can be used up instantly. McCoy[14] states, "If we get improper de-oxidation that takes place when aluminum comes into contact with the slag we run into type two inclusions and our ductility drops off almost 50 per cent".

One of the major causes for variation in RA is tapping slag and metal into the ladle together. The tap hole must be small enough, and the furnace tipped quickly, so the metal is tapped out from under the slag. This permits the metal to be completely de-oxidized before the slag comes out of the furnace.

Figure 9 shows the enlarged tap hole which permits slag to exit with the metal. This figure also shows the same tap hole rammed to the proper size.

Figure 10 shows the microstructure resulting from high FeO in tapping slag and poor tapping practices.

As long as the bath contains dissolved FeO, it should not absorb hydrogen. However, the FeO must be removed before the metal is cast. Sufficient de-oxidation is obtained by adding enough manganese to leave a minimum of 0.40 per cent in the metal, and enough silicon to leave a residual of 0.30 per cent or higher, plus 2 lb aluminum per ton. When these de-oxidizers have been added, the metal is in a state to absorb hydrogen. The electrodes should on no account arc on the metal after de-oxidation.

Heats tapped at 3150 F can be de-oxidized in the ladle. Heats tapped at 2960 F can be partly de-oxidized in the furnace prior to tapping.

Before the steel foundry melter can make the best use of special de-oxidizers, he must solve the problem

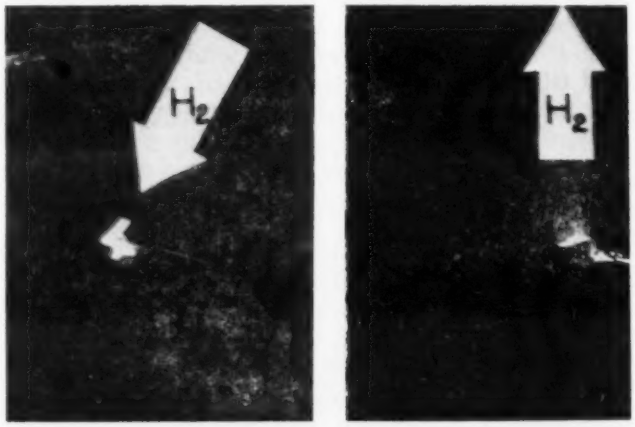

Fig. 8 — The dead test indicates gas conditions in the bath.

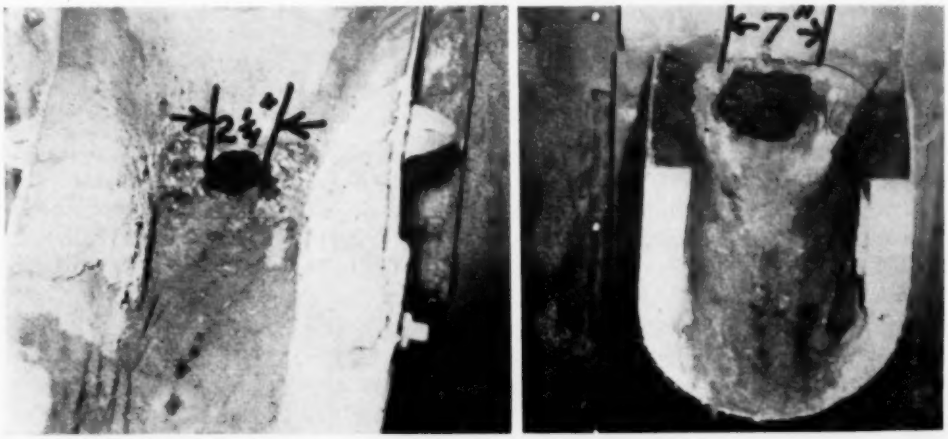

Fig. 9 — Size of tap hole may determine metal quality. Left — Tap hole right size; Right — Tap hole too large.

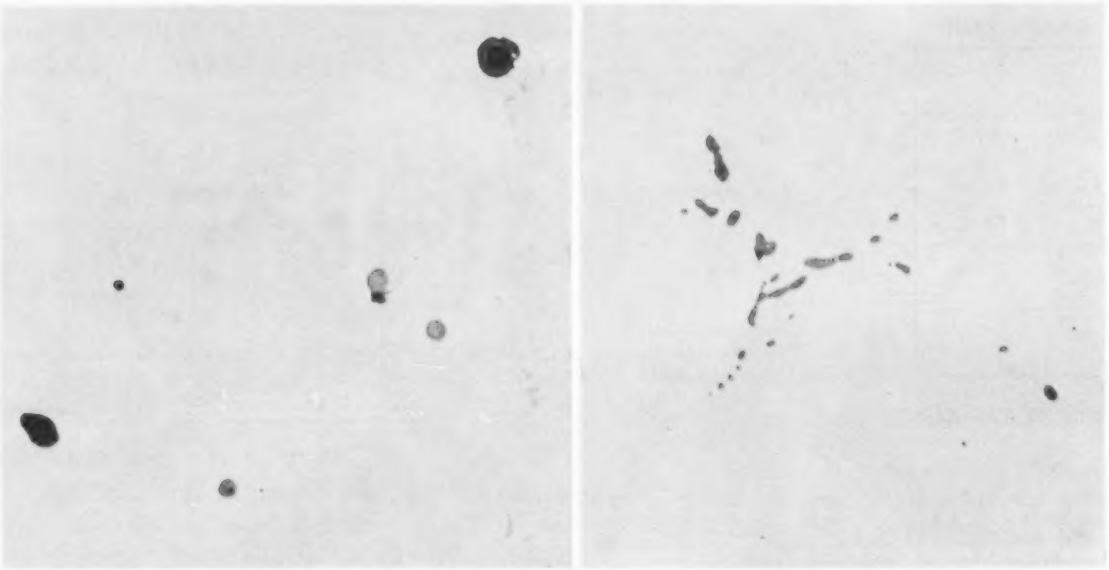

Fig. 10 – Effect of slag on metal quality. Left – normal basic steel; Right – poor quality due to inclusions. Unetched, 500×.

of controlling the FeO content in the final slag and metal. The problem of tapping a heat without slag-metal reaction in the ladle must also be controlled.

The oxides of silicon, aluminum, calcium, chromium, and magnesium present in furnace refractories all have high melting points. These oxides float to the top of the ladle and present no hazard to quality.

Calcium silicates and iron silicates having lower melting points, make a thin slag that is difficult to separate from the metal and may show up as slag spots in the castings. Careful skimming and gating practices can minimize this type of defect.

Iron oxide and FeS are the main agents in forming non-metallic inclusions. They are dissolved in the metal and precipitate out on solidification. Crafts and Hilty[15] have shown the phase relationships which determine whether favorable or detrimental inclusion patterns will result. Figure 10 shows two types of inclusions. A slight change in de-oxidation balance resulted in a difference in RA of more than 20 per cent in this case.

Better methods of slag testing, and better control over tapping practise, are required in order to bring non-metallic inclusions under control.

CONCLUSIONS

1. Sulfur over 0.030 per cent will cause lowered ductility.
2. Carbon contents above 0.33 per cent result in lower toughness than is obtained in 0.20–0.30 C steel.
3. Each ppm of hydrogen may lower reduction of area (R.A.) by 10 per cent.
4. Boiling the bath improves metal quality. The boiling operation can be measured by means of carbon and manganese tests.
5. The amount of FeO in the slag before tapping has an effect upon reduction of area. The optimum FeO content varies depending upon tapping temperature. Acid heats tapped at 3150 F have the highest RA when the final slag contains about 10 per cent Fe.
6. Metal in the furnace should always contain FeO. This is assurance against hydrogen pick up.
7. Tapping temperature must be high enough to allow entrapped non-metallic inclusions to float to the top of the ladle. A minimum tapping temperature of 2950 F is recommended.
8. Tapping must be done so as to prevent slag-metal reaction in the ladle.

Some of the factors affecting reduction of area values of mild steel test bars have been discussed. Absolute control over these factors is not yet possible.

Rapid tests for hydrogen in steel, FeO and MnO in slag, and FeO in steel would be helpful.

REFERENCES

1. "Control of hydrogen in electric furnace melting," Howard M. Germain, *Proc. Electric Furnace Steel Conference* A.I.M.M.E., 1943, p. 150.
2. Discussion by W. B. Arness, *Electric Furnace Steel Conference*, A.I.M.M.E., 1943, p. 154.
3. "Hydrogen and Nitrogen Contents of Steel," Sims, Moore and Williams, *Proc. Electric Furnace Steel Conference*, A.I.M.M.E., 1947, p. 106-123.
4. Discussion by C. B. Post, *Proc. Electric Furnace Conference*, A.I.M.M.E., 1947, p. 124.
5. "Rapid Hydrogen Analysis and Some Applications," W. A. Peiffer, *Proc. Electric Furnace Steel Conference*, A.I.M.M.E., 1956 *Vol* 14, p. 174-181.
6. "Quality of Oxygen-decarbonized Steel," C. A. Faist and Clyde Wyman, *Proc. Electric Furnace Steel Conference*, A.I.M.M.E., 1949, *Vol.* 7 p. 219.
7. "A Review of Metallurgical Practices and Their Effects," C. E. Sims, *Proc. Electric Furnace Steel Conference*, A.I.M.M.E., *Vol.* 10 1952 p. 152.
8. "Effect of Some Melting Variables on theTensile Properties of Acid Electric Steel," Sam F. Carter, *Proc. Electric Furnace Steel Conference*, A.I.M.M.E., 1947, p. 182-196.
9. "Slag Control in the Acid Furnace," H. H. Johnson, M. T. McDonough and D. L. Radford, TRANSACTIONS AFS, 1947, *Vol.* 55, p. 520-532.
10. "Slag Control," C. H. Herty, Jr., *Transactions*, A.I.M.E., *Vol.* 140, p. 13 (1940).
11. "Acid Electric Furnace Slag Control," J. W. Juppenlatz, TRANSACTIONS, AFS, 1942, *Vol.* 50, p. 322-336.
12. "Slag Treatment for conservation of Chromium," T. W. Merrill and F. S. Vincent, *Proc. Electric Furnace Steel Conference*, A.I.M.M.E., *Vol.* 11 p. 69-77.
13. "The Perrin Process," Jerome Strauss, *Proc. Electric Furnace Steel Conference*, A.I.M.M.E., 1946, p. 236-240.
14. Discussion by H. R. McCoy, *Proc. Electric Furnace Steel Conference*, A.I.M.M.E., 1943, p. 221.
15. "Sulfide and Oxide Formation in Steel," Walter Crafts and P. C. Hilty, *Proc. Electric Furnace Steel Conference*, A.I.M.M.E., 1953 p. 121-144.
16. M. V. Healey, *Steel*, August, 1949, p. 104.

LADLE HEATING IN THE FOUNDRY

By
Randolph B. Renda* and William M. Zeunik**

INTRODUCTION

The object of this experiment was to determine the most efficient and economical way of heating ladles. Determination of the following, by using different methods of heating and different types of burners, were also included:

1. The maximum temperature that can be attained in ladles.
2. The time required to obtain this maximum temperature.
3. The temperature gradient obtained in the lining of the ladle.

The two different types of burners used were a) premixing, and b) aspirator.

To clarify the results obtained from each burner, this experiment was divided into two parts. Each part deals with one type of burner.

PREMIXING BURNER

An investigation of different methods of heating a ladle by a premixing burner revealed that the method in use in the plant is the most effective. It also revealed the existing installations of these burners, now being used, are not in accordance with the manufacturer's recommendations. This fact was a possible explanation of the inefficiency of the premixing burner in comparison with the aspirator-type burner.

Apparatus and Method for Heating a Ladle with a Premixing Burner

A 250-lb ladle was lined in the usual fashion with a proprietary material. The composition of this material is crushed firebrick and rock. The thickness of the lining varied from 1½ to 2 in.

Seven thermocouples of chromel-alumel composition were inserted into the lining. These were pushed into the lining from the outside through ½-in. holes cut in the ladle. Five of these holes were located in the back-side of the ladle. Through these holes five thermocouples were inserted into the lining to various depths. One thermocouple was placed at the bottom and one in the front underneath the lip. Temperatures were read with an indicating pyrometer.

The setup used in heating the ladles for this part of the experiment is shown in Fig. 1.

The premixing system mixes any clean gaseous fuel with air drawn in from the atmosphere through the ratio-valve on the blower inlet. The air-gas mixture formed is delivered by means of suitable piping to one or more burner nozzles. The combustion mixture is directed through the nozzles and burned.

The equipment used consisted of:

1. The premixing burner proportions and premixes the air and gas for combustion. It then delivers the mixture under pressure to the burner nozzles. The recommended manifold pressure at the nozzle farthest removed from the burner is 0.4 in. water column. (1.75 in. of water column equals 1 ounce per sq. in.)
2. A safety shut-off valve provides automatic closing of the fuel line in case of interruption or failure of the electric current.
3. A main gas shut-off cock is used to manually shut off the gas to the unit.
4. Burner nozzles of 1½-in. were used to direct and maintain ignition of the gas-air mixture supplied.

The recommended installation setup includes a gas-pressure regulator which is used to eliminate fluctuations in the gas supply pressure caused by the operation of other units on the same supply line. It is also recommended that the gas pressure regulator be adjusted for a downstream pressure of 2 ounces (3.5 in. of water column) while the unit is operating wide open.

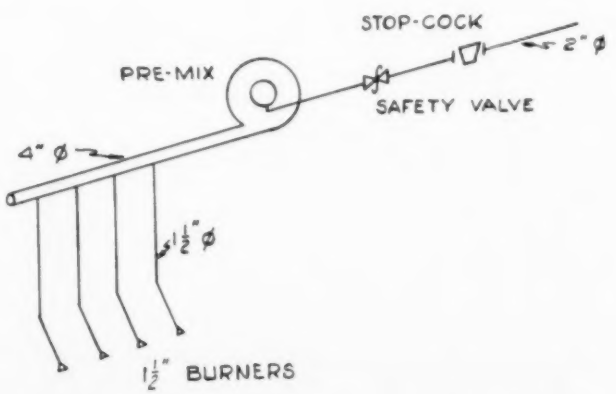

Fig. 1—Setup used in heating ladles for premixing burner tests.

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All of the above recommendations are made on the assumption that the gas supplied to the unit at the pressure-regulator inlet varies between 2 ounces and 8 ounces per sq in. However, results of the tests have indicated that for the present installations there is a gas pressure of 0.0 to 0.1 ounces in the gas supply lines to the units while all the units are in operation.

5. The gas pressure capacity is 2 ounces at the premixing inlet. The firing rate is 900,000 Btu per hr. In a setup where four burner nozzles are being supplied by one premixing unit, the capacity per burner is 225,000 Btu per hr. Since the gas being supplied has a rating of 570 Btu per cu ft, each burner has a capacity of 440 cu ft per hr under recommended operating conditions.

TESTS MADE

TEST 1—A ladle was heated in the manner shown in Fig. 2. The flame was directed into the spout; the ladle was closed with a steel lid.

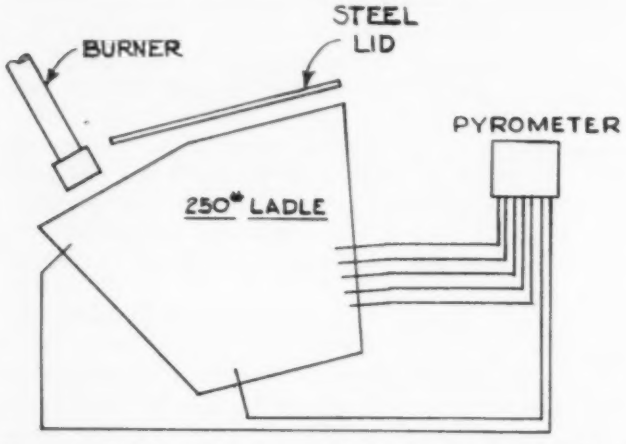

Fig. 2—Method of heating ladle for test one—premixing burner.

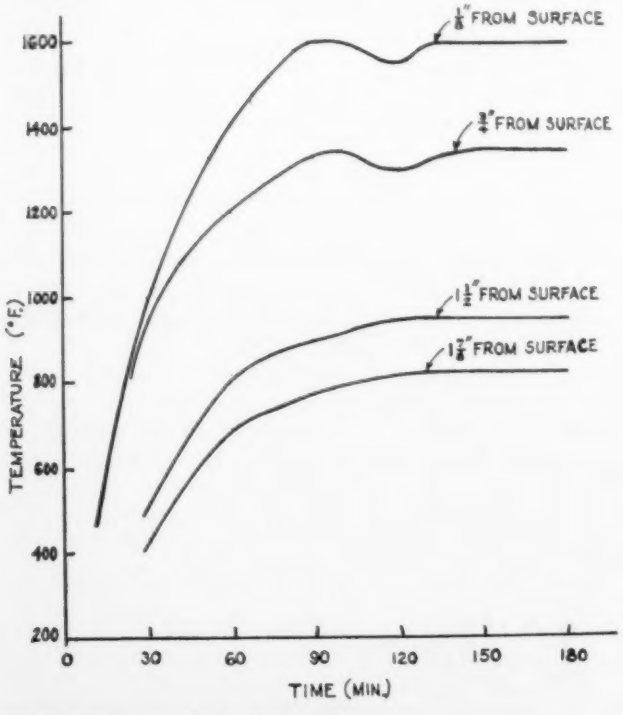

Fig. 3—Thermocouples in back wall.

This ladle was heated for a period of 3 hr. Temperature readings were taken at one min intervals for the first 15 min, and at 5-min intervals for the rest of the test. Maximum temperatures obtained in the heated side of the lining 1/8-in. from the surface were 1600 F and 800 F on the opposite side 1/8-in. from the outer surface. It took one hr and 30 min of heating to reach equilibrium.

Temperature—time curves are shown in Fig. 3. Temperatures observed gave a temperature gradient that was a linear function of the distance from the heated surface. The slope depended upon the thermal conductivity (K) of the lining material, which was in the range 0.70 to 0.85.

Figure 4 shows that parts of the ladle reach equilibrium temperatures long before another part does. There is a considerable difference in temperature in different parts of the ladle lining. This could well have been due to the manner in which the flame of the burner impinges on the ladle lining.

After about one hr and 40 min there was a noticeable decrease in the maximum temperature registered. The reason for this was investigated during the next run which continued for 8 hr. It was observed that the maximum temperature decreased about 100 F whenever the other two units drawing gas from the same main gas line were put into operation. This effect can be seen in Fig. 3.

This was believed due to the absence of gas pressure regulators, and to the low gas pressure in the main line. In checking for the cost of this type of ladle heating, the gas meter was clocked while nine of the 12 burners were in operation. The rate of gas consumption was 48 cu ft per min. Based on this figure, the actual rate of firing per burner was found to be 320 cu ft per hr. This makes the cost of heating one ladle 19 cents, or a cost of 4 cents per 100 cu ft of gas.

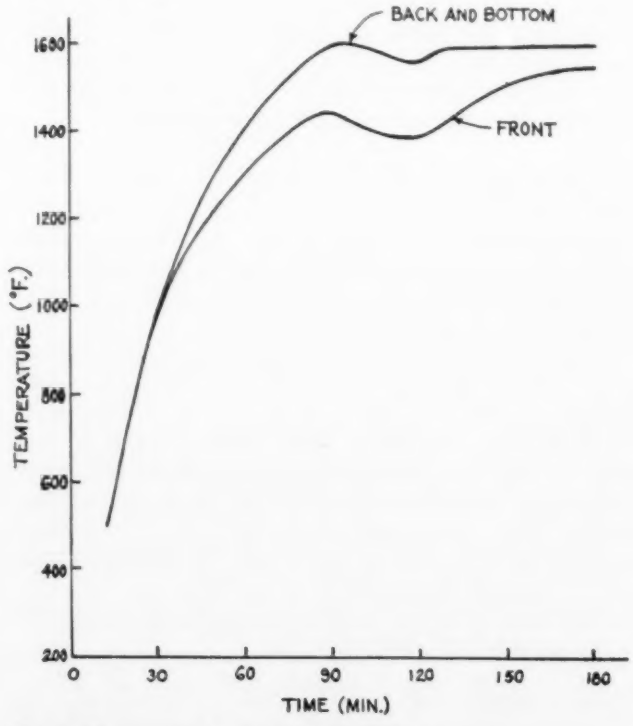

Fig. 4—Thermocouples 1/8-in. from surface.

In the subsequent tests only a few of the available curves are shown in order to simplify the graphic presentation.

TEST II—For this test the ladle was turned around and heated from the back through a hole cut in the lid. This is shown in Fig. 5.

The test coincided with the second day of a three-day shutdown. This meant that the other two units on the same main gas line were turned off all day. The flame was neutral to oxidizing and steady all during the day.

The heating method used in this test did not seem to be as efficient as the previous method. This was because flame escaping through the lip, and the subsequent creation of a draft, carried away the convection heat at a rapid rate. The effectiveness of the conduction heat in the ladle lining was thus reduced.

The observed maximum temperature was 1600 F registered by the thermocouple placed underneath the lip. Compensating for the fact that this thermocouple was on the surface of the lining would reduce this temperature to about 1500 F. Figure 6 shows the temperature–time curves obtained.

According to the literature furnished by the manufacturers, it is desirable to maintain a balance or slightly positive internal pressure (0.0 in. to 0.5 in. of water column) in the ladle. This is to secure maximum efficiency and the most effective combustion. Higher internal pressures reduce the capacity of the premixing unit, and maximum operating temperatures.

TEST III—A different method of heating was employed for this test, as seen in Fig. 7. An insulating brick wall was built around the burner nozzle. The ladle was put above this wall in an inverted position.

This test continued for 3 hr (Fig. 8). The maximum temperature reached was 1300 F. This was after making corrections and considering the fact that the thermocouple nearest to the surface of the lining was 3/8-in. The explanation for this relatively low maximum temperature seemed to lie in the fact that the coefficient of radiant heat transfer for the insulating bricks was lower than that of the iron lid of the ladle. When the ladle was being heated in the usual fashion, as in Test 1, the lid became red hot and reflected part of the heat it absorbed as radiant heat to the surface of the lining.

TEST IV—For this test (no photographic record is available) the method of catching iron from the furnace was utilized to heat the ladle. First the ladle

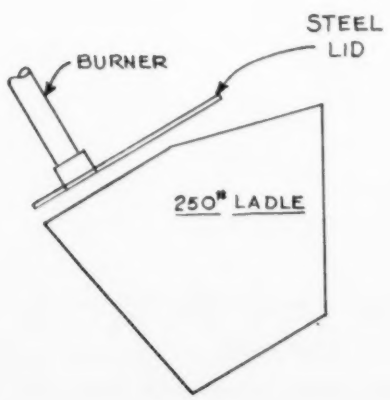

Fig. 5—For test 2, premixing burner, the ladle was heated from the back.

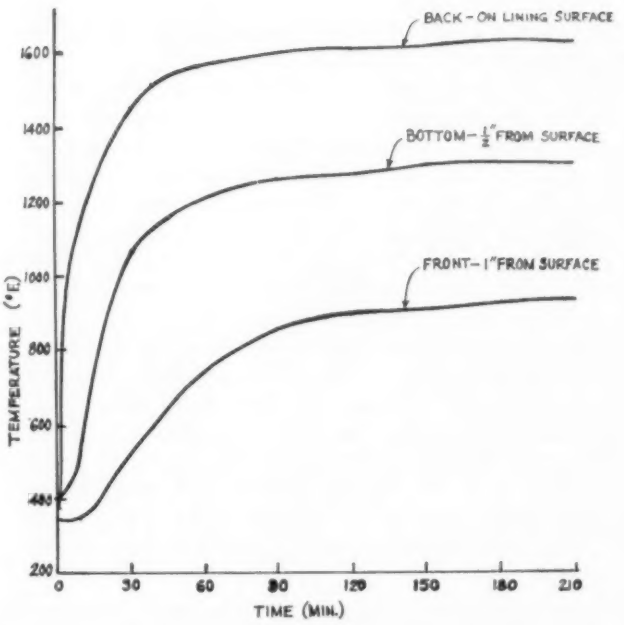

Fig. 6—Temperature-time curves, test 2, premixing burner.

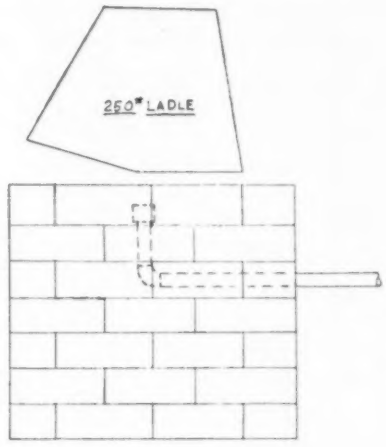

Fig. 7—Method of heating, test 3, premixing burner.

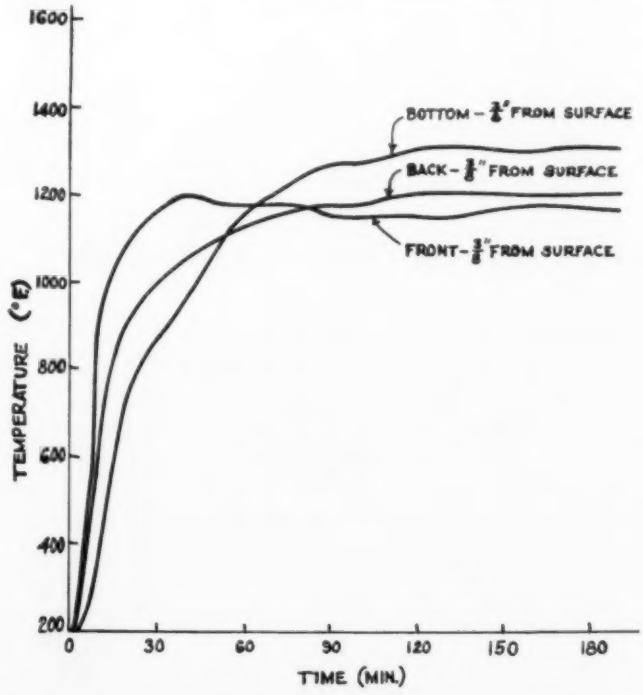

Fig. 8—Temperature-time curves, test 3, premixing burner.

was heated with gas for 3 to 4 min until the temperature of the lining reached 200-250 F.

Then the ladle was moved to the furnace along with the thermocouples and the pyrometer. It took 27 sec to fill the ladle with molten iron at a temperature of about 2800-2900 F. Another min was required to move the ladle out of the way. The molten metal was kept in the ladle for 5 min and then poured out. This operation took one min and 30 sec. Catching the next iron required 24 sec. This was kept in the ladle for 11 min before pouring it out.

This whole test took exactly 20 min. The maximum temperature registered was 1690 F which was observed after 14 min of the test were completed. This was 7 min after the ladle was filled with the molten metal for the second time (Fig. 9).

According to the figures available it costs $10.00 to heat up 20 tons of molten metal each additional 200 F. It would cost 12 cents to heat 250 lb of molten iron from 2400 F to 2800 F. The cost of heating a ladle for this experiment by utilizing molten metal was 24 cents.

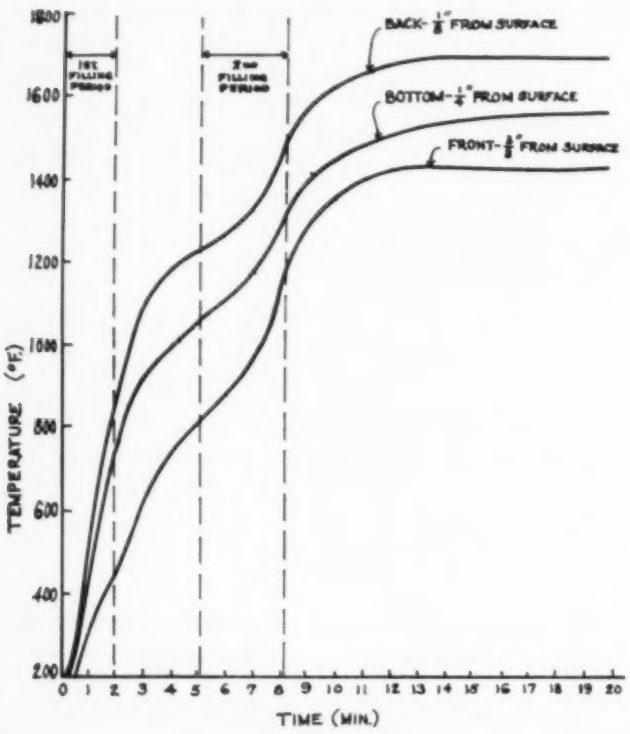

Fig. 9—Temperature-time curves, test 4, premixing burner.

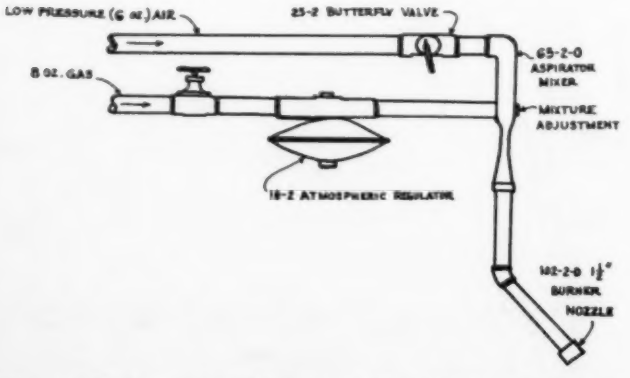

Fig. 10—Equipment used for tests with aspirator-type burner.

ASPIRATOR-TYPE BURNER

Apparatus and Method for Heating a Ladle with the Aspirator-Type Burner

The second part of this experiment consisted of heating a ladle in the usual fashion by using a low-pressure aspirator-type burner.

An aspirator-type burner operates on the same principle as a carburetor. Air under slight pressure passing through a throat or venturi mixer pulls the gas, due to moving air inertia, from the gas pipe opening into the mixer. The pressure of this gas is reduced to zero absolute or to atmospheric pressure through a pressure regulator before it opens to the venturi mixer.

The gas supplied was supposed to be about 2.5 lb per sq in. However, the gauge registered a pressure of only 8 ounces at the intake to the atmospheric pressure regulator.

Low pressure air was supplied by a blower.

Figure 10 lists equipment used.

An 18-2 atmospheric regulator reduces the pressure of the gas to atmospheric pressure by the use of a diaphragm before the gas enters the venturi-aspirator mixer.

A 25-2 butterfly valve regulates and adjusts the amount of air to be passed through the aspirator to obtain the proper and efficient air-gas mixture.

The 65-2-0 aspirator mixer regulates air flowing through the mixer. This accelerates by the venturi effect created with a resulting air pressure drop. This is caused by conversion of a portion of its pressure

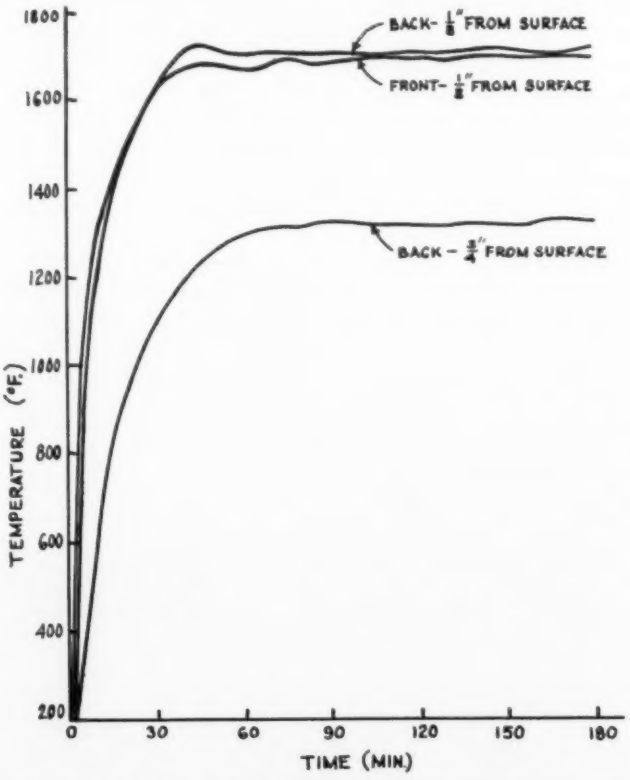

Fig. 11—Temperature-time curves, aspirator-type burner test.

head to velocity head to give this higher velocity. The higher velocity and lower pressure causes the gas to flow into the mixer where the proper mixing takes place.

The 102-2-D 1½-in. burner nozzle directs and maintains ignition of the mixture supplied. Its capacity is 280,000 Btu per hr, or 440 cu ft per hr.

This test was run for 3 hr. A maximum temperature of 1700 F was observed after 35 min heating. (Data are plotted in Fig. 11).

The higher maximum temperature obtained in a shorter period of heating (compared to the preceding tests) was believed the result of better control of the combustible mixture.

The cost of heating one ladle for 35 min was eight cents.

Another burner of the aspirator type was tested and found less efficient than that described here. This second burner (of different make) heated more slowly. It did not give more than 1600 F temperature of the lining.

CONCLUSIONS

The results of the tests conducted for Part I of this experiment indicate that the manner in which the ladles are being heated at the present time (ladle right side up, lid on and closed, flame applied at the lip of the ladle) is the most efficient. Explanation for this is that it is possible to maintain a balanced or slightly positive internal pressure in the ladle by this method. Also there is also a radiant heat exchange between the red-hot lid and the lining of the ladle.

A comparison of the results obtained from the three different burners used points to one of the aspirator type as the most efficient and economical under the conditions employed here.

To reach a maximum temperature of 1600 F with a premixing burner required one hr and 30 min heating at a cost of 10 cents.

The aspirator type burner required a heating period of only 35 min to reach a maximum temperature of 1700 F at a cost only eight cents.

With the other burner 1½-hr of heating brought the maximum temperature to 1600 F at a cost of 20 cents.

These costs compare with 24 cents for heat lost from molten iron to the lining of an unheated ladle.

In comparing the above results it should be kept in mind that the premixing burner was not operating under the recommended conditions.

A CASTING TECHNOLOGY FOR REACTIVE METALS

By
F. W. Wood*, S. L. Ausmus**, and E. D. Calvert***

ABSTRACT

The equipment and practices employed in consumable-electrode, cold-mold arc-casting are briefly described. Some cast products are illustrated and their quality is discussed. Major areas of potential process improvement are noted. Average pouring temperatures between 3300F and 4500F, electrical efficiencies between 15 per cent and 60 per cent, and metal yields between 30 per cent and 75 per cent were revealed by a study of operating variables and their effect on furnace performance for titanium casting. Low carbon contamination is reported when molds of commercial graphite are used. A comparison with rammed graphite molds is made. Practicality, efficiency, reliability, and versatility are claimed for the process.

INTRODUCTION

This paper will review a system of reactive metals casting developed, practiced and still undergoing extension and refinement at Bureau of Mines laboratories in Albany, Oregon. The basic techniques and equipment will be described, some of the capabilities as demonstrated by experimental casting will be cited, and finally certain process variables will be discussed.

The present casting system has evolved from work on the casting of titanium begun in 1953, and originally supported by Watertown Arsenal Laboratories. The Atomic Energy Commission has sponsored adaptation of the method to zirconium, hafnium, and other nuclear-age metals. The Bureau of Mines is continuing, under its program, research on titanium casting. The status of development as of July, 1955 has ben reported previously.[1]

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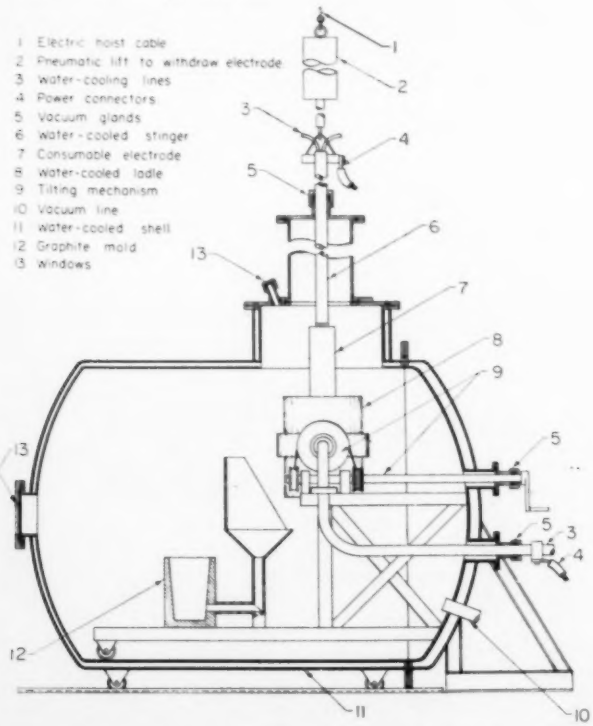

Fig. 1 — Schematic drawing of consumable-electrode arc-casting furnace.

PRACTICE AND EQUIPMENT

In essence, the casting method is a modification of conventional consumable-electrode arc melting in a water-cooled copper crucible. The principal difference in equipment is the design and mounting of the crucible. In standard arc-melting furnaces, the crucible is rigidly mounted and its water jacket is usually removable. In a casting furnace, the crucible and its water jacket are integral, constituting a trunion-mounted ladle that can be tilted to pour the molten portion of its charge over the lip.

A relatively thin solid shell or skull of metal is left behind in contact with the cold copper ladle. This skull may be left in place for succeeding cycles with the same metal or alloy. The techniques of operation are also similar to those for normal arc melting, except that in casting the range of effective conditions is narrower. Of course, entirely new problems foreign to conventional arc-melting operations are introduced in connection with materials and designs for molds.

A typical consumable-electrode arc casting furnace is illustrated schematically in Fig. 1. An overhead suspension (1)* from an electric hoist supports the electrode assembly. Gravity advances the electrode as the suspension is lowered. An important link in the electrode assembly is a pneumatic cylinder (2) that withdraws the electrode (7) rapidly from the ladle (8) at termination of the arc. Delays are avoided by this method in transferring molten metal from the ladle to the mold (12). Flexible hoses (3) carry cooling water.

Flexible cables (4) or water-cooled copper brushes faced with graphite deliver electrical power (usually

*Numbers in parentheses refer to numerals on the figure.

negative potential) to a hollow copper shaft (or stinger) (6). This slips through a vacuum gland (5) to support the consumable portion of the electrode assembly. When the desired length of electrode has been consumed and the remaining electrode has been withdrawn, the ladle is tilted by torque applied to a shaft outside the furnace and transmitted through another vacuum gland (5) to either a simple drum and cable (9) or a spur-gear transmission.

The ground power connection (4) is made to heavy-walled copper pipe (3) that carries cooling water through still another vacuum gland to the ladle. The water-cooled furnace shell (11) is evacuated both before and during operation through a port (10) leading to a mechanical vacuum pump. The Bureau of Mines uses 100 to 300 cfm capacity pumps in experimental operations. However, since evacuation time represents a major portion of the operating cycle, larger pumps would be advantageous in commercial installations.

Several glass view-ports (13) are provided for observation. The danger of an explosive interaction between molten metal and water in the event of ladle rupture makes remote operation mandatory. Images from the view-ports are projected through an optical system to a screen at the remote operating site.

In operation, reactive molten metal must be protected from active gases. For casting purposes a vacuum is much preferred over an inert atmosphere. Pressure is usually allowed to seek an equilibrium value depending on pump capacity and the evolution rate of gases and vapors from molten metal. Care must be exercised to avoid an anomalous nonconsuming form of discharge (similar to glow discharge) which can occur at lower pressures.

It has long been suspected and recently confirmed by experiments[2,3] that even though superficial pressures as low as 0.0005 mm may be indicated, equilibrium pressures at the surface of molten metal are typically in the range from 0.1 mm to 3 mm. Although not verified by experiment, there are good reasons to believe that equilibrium pressures as high as 20 mm may exist under some circumstances.

Arc currents for titanium casting range from about 7,000 amps for a 25-30 lb pour to about 11,000 amps for a 180 lb pour. Vacuum arcs at these currents require about 30 volts.

The molds most commonly used in static casting are semi-permanent assemblies of machined graphite. As illustrated by Fig. 2, these molds can be relatively complex. A laminar structure is employed to avoid re-entrant angles on any one mold section. In some cases they are used to allow transposition of draft from a cast surface to an interface between mold sections. A more complete description of such molds may be found elsewhere[4].

Despite complexity, graphite molds can be produced in quantity at a unit cost in the order of $3.50 per lb of graphite in the finished mold. Normally, molds may be used dozens of times before replacement is necessary, making them much less expensive than might be imagined.

In experimental casting of titanium, machined graphite mold costs, reusing molds 8 to 10 times, have averaged $2.60 per lb of finished casting. Any commercial grade of graphite can be used, but superior results are realized with dense grades having low ash contents. Should a large demand for graphite molds arise, at least one major producer of commercial graphite has expressed interest in molding shapes for casting by the same method used for molding commercial graphite stock. The probable cost is near $0.25 per lb of graphite.

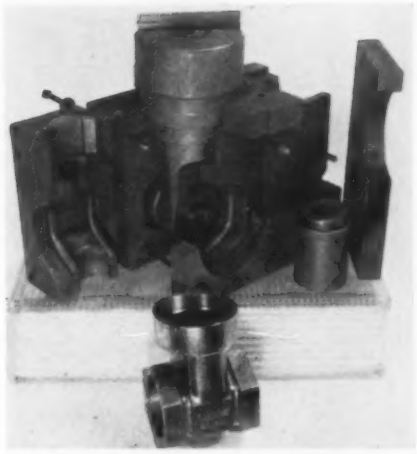

Fig. 2 — Machined graphite valve body mold.

As an attractive alternative to commercial graphite, various binders may be used to prepare graphitic ramming mixtures.[5] Appropriate firing of rammed shapes produces molds somewhat less durable and slightly more susceptible to attack than machined graphite molds. Although many unfavorable reports have been made, special oxide refractories cannot be excluded as a second alternative for many purposes.

An interior view of an arc-casting furnace is shown in Fig. 3. In this furnace a centrifugal mold is mounted in position to be spun on a horizontal axis. These molds are steel tubes with graphite inserts machined to the desired casting shape. Also shown in the figure are a copper ladle at the upper right, a ball-bearing union joint in the right foreground, and a graphite sprue system that funnels molten metal into the spinning mold near the center.

EXPERIMENTAL CASTINGS

Figures 4 and 5 show three titanium valve shapes. Except for seats and threads, the surfaces are as-cast, showing the excellent mold reproduction and the

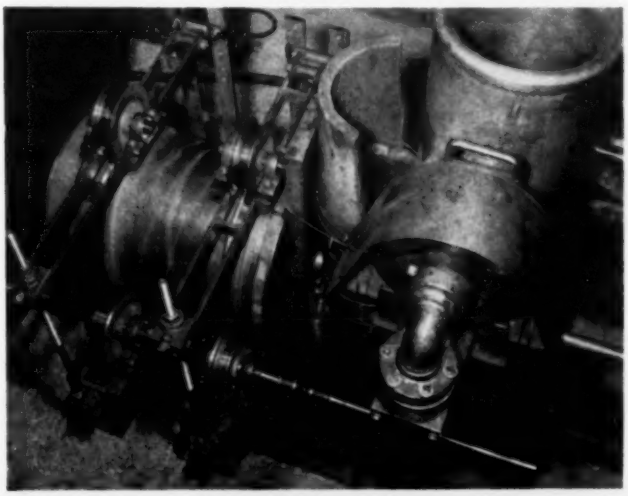

Fig. 3 — Interior of consumable-electrode arc-casting furnace.

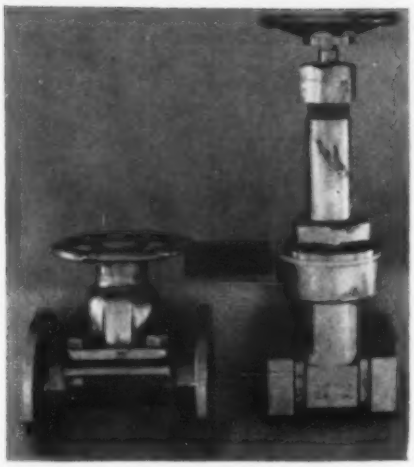

Fig. 4 – Cast titanium valves.

Fig. 5 – Cast gate valve assembly.

Fig. 6 – Spin cast hafnium tube.

absence of mold reaction attainable by static casting in machined graphite. In October, 1957, a series of the gate valves shown in Fig. 5 was placed in industrial service to evaluate performance. They were subjected to: a) water containing 2,000 ppm chloride at 284 F (140 C), b) 65 per cent nitric acid at 230 F (110 C), and c) 15 per cent sodium hypochlorite at 194 F (90 C).

The same valves were hydraulically tested, and all seats and gasket seals were found to withstand at least 500 psi of sustained pressure. This was the upper limit of the hydraulic testing equipment.

A short section of six-in. hafnium tube is shown in Fig. 6. This tube was produced by spin casting and is shown in as-cast condition. Similar tubes of zirconium with heavier walls have been successfully used as extrusion blanks. Figure 7 shows three 18 ft lengths of tubing extruded from three separate centrifugally-cast blanks. In one instance, extrusion was performed with outside surfaces of the blank still in the as-cast condition. In the other two cases, all surfaces were machined lightly before extrusion. This practice saves valuable metal by reducing machining losses.

Another variation of the spin-casting technique is illustrated by Fig. 8. This is a length of finned-copper tube produced in connection with a heat transfer problem under a separate study. Admittedly, copper is not normally classed as a reactive metal, but since it was treated as such the experiment is still of interest. The figure also shows additional details of centrifugal mold construction.

How good are these castings? Twenty-five zircaloy-2 brackets as shown in Fig. 9 are fairly typical of static castings and will be described in answer to this question. Surfaces were generally smooth, with a few superficial folds or wrinkles caused by the high rate of heat loss to the graphite mold. In color the surfaces ranged from bright to light shades of tan or gray. Micrometallography of surface sections revealed that there was carbon contamination extending to a maximum depth of 20 mils (0.020 in.). Analysis of

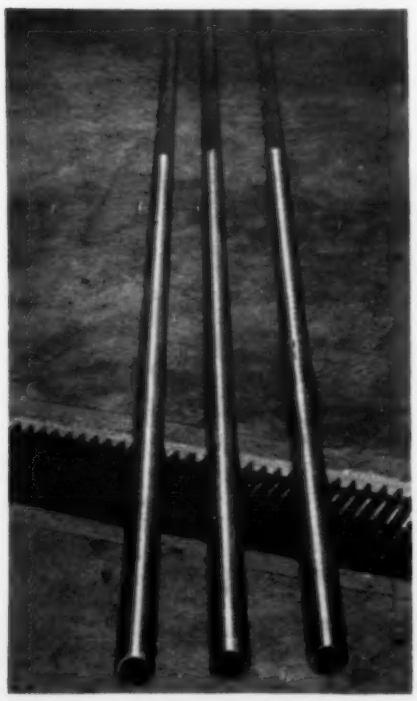

Fig. 7 Left – Tubes of zircaloy extruded from cast blanks.

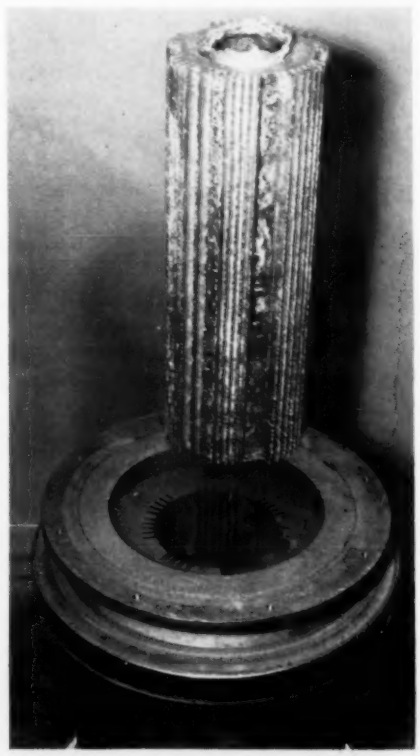

Fig. 8 Right – Finned copper tube and mold.

samples collected from the first five mils under the surface indicated 400 to 600 ppm of carbon. Analysis of samples from the entire 20 mils of surface contamination indicated 200 to 400 ppm of carbon. Above about 500 ppm, carbon contamination causes a slight increase in the corrosion rate of zirconium, but this increase does not become serious until contamination exceeding 1,000 ppm is reached.[6]

Internally, the bracket castings contained scattered porosity, mostly of the pin-hole variety. In a few instances these approached 1/8-in. in dimension. The soundness was adequate for normal corrosion service but failed to meet the usual aircraft-type specifications. However, it is believed that aircraft quality can be obtained through improved design of static molds or resort to centrifugal-casting techniques.

Several brackets were subjected in their entirety to corrosion by steam at 750F and 1,500 psi for three days. The result was a normal lustrous black oxide layer. No white corrosion products were formed. Standard corosion coupons were also collected and subjected to 750F steam at 1,500 psi for a total of 98 days. The results are compared with typical behavior of wrought metal in Table 1.

Mechanically, the 0.2 per cent yield strength averaged 49,600 psi, tensile strength averaged 66,600 psi, and reduction in area at the fracture averaged 36 per cent. These values are typical of hot-rolled metal of the same composition. The thin wall-sections of the cast brackets necessitated a substandard Charpy V-notch test. A special series of specimens from wrought metal were tested for comparison. The cast specimens were tested by a company[7], and were found to possess about one-half the impact resistance of wrought metal at room temperature and at 200F.

PROCESS VARIABLES

Largely as a result of trial-and-error, practical results have been obtained, but there are several areas of potential improvement. The need for further development of mold designs and materials or other changes leading to reduced costs and improved casting soundness has been inferred. The use of vacuum techniques probably has not been fully exploited for maximum improvement of product quality.

A continuation of trial-and-error methods should yield progress toward these objectives, but approaches to the problems would certainly be clarified by knowledge of metal temperatures, operating efficiencies, etc. Accordingly, the Bureau of Mines conducted a preliminary investigation of dependent variables as functions of operating conditions.

Specifically, the yield of metal (per cent of charge poured), the distribution of heat, metal temperatures, melting rates, and the reaction of molten metal with mold materials were studied. They were studied as arc current, pressure, electrode and ladle diameter, alloy composition, and casting sizes were varied.

Two separate series of zirconium casting heats were conducted to establish the influence of electrode diameter on the yield of metal. The first series consisted of three heats, all made without benefit of initial skulls. The test was made in a 9-1/2-in. diameter ladle, at nominal currents of 8,000 amps, and at nominal pressures of 100 to 200 microns. The only deliberate difference between heats was the electrode diameter.

As an extra precaution, all electrodes were fabricated from the same ingot stock to minimize variation of metal composition.

The results are given in table 2.

A second series of three heats followed. The same procedure was used except that the ladle was 8-1/2-in. in diameter, pressures were more nearly 400 microns, and a lower range of electrode sizes was employed. Results are given in Table 3.

The minor differences are no more than might be expected from such things as cooling irregularities. A conclusion that electrode size has no bearing on yield must be qualified by the admission that skull weights usually increase slightly to some equilibrium value over the first several successive melts. This weight increase is principally a build-up at the upper rim of the skull. It is suspected that the ultimate build-up is greater for smaller electrodes.

A larger series of experimental heats with titanium alloys furnished information on the remaining variables. This series included six levels of arc current, three distinct ranges of pressure, three ladle sizes, and

TABLE 1 – CORROSION RATES OF CAST AND WROUGHT ZIRCALOY

Time-days	Weight Gain, mg/cm²	
	Ave. of Cast Brackets	Typical of Wrought Metal
14	2.80	3.5
28	3.97	4.5
42	4.50	5.5
56	6.22	6.5
70	6.84	7.5
84	8.07	8.5
98	9.39	9.5

TABLE 2 – FIRST SERIES HEATS TEST RESULTS

Heat No.	Electrode Diam., in	Residual Skull Wt., lb.	Wt. Poured, lb	Yield %
SA 11366	8	39.2	75.0	65.5
SA 11367	6	34.0	75.0	68.8
SA 11370	4	34.4	71.0	67.3

TABLE 3 – SECOND SERIES HEATS TEST RESULTS

Heat No.	Electrode Diam., in	Residual Skull Wt., lb.	Wt. Poured, lb	Yield %
SA 11557	6	15.9	40.1	71.6
SA 11558	4-3/8	13.2	40.1	75.1
SA 11559	3	13.2	40.6	75.4

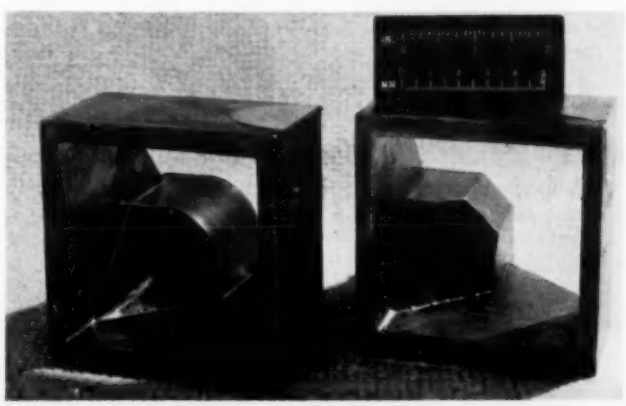

Fig. 9 – Cast zircaloy structural brackets.

four alloy compositions. Each of the various water cooling loops associated with the casting furnace was equipped with a flow meter and iron-constantan thermocouples for continuous recording of coolant volume and temperature. These data were used to calculate the relative distribution of heat to the various furnace components as a function of time.

Strip-chart-records of current, potential and time supplied a total energy in-put figure for each heat. This was proportioned and assigned in accordance with the heat distribution deduced from water temperature and volume data. From the assignment of energy to the molten and solid portions of the charge, average molar heat contents and average metal temperatures were computed. As a matter of standard practice, weights were obtained which allowed the calculation of metal yields and average melting rates.

Each pour was made into a network of cubical-mold cavities ranging in size from 1 in.-8 in. Most molds were of machined graphite, but in several instances sizes up to 4 in. were duplicated with mold components of rammed graphite furnished by Frankford Arsenal. Direct comparison was possible between the various sizes and between the two mold materials. Operating data are summarized in Tables 4, 5, 6, 7.

The choice of method for temperature estimation is open to criticism. It was selected because the temperatures are too high for conventional probe measurements, and pyrometry is complicated by ionized vapors and reflection of an electrode image from the molten pool surface. In addition, it was decided that an average temperature is more significant than a localized temperature.

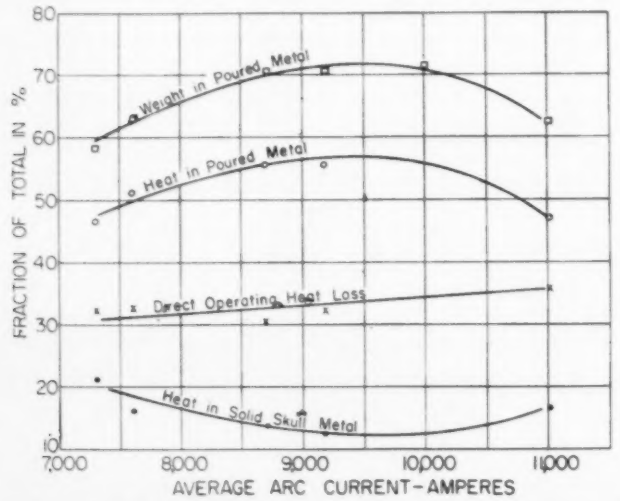
FRACTION OF TOTAL IN %
Weight in Poured Metal
Heat in Poured Metal
Direct Operating Heat Loss
Heat in Solid Skull Metal
AVERAGE ARC CURRENT-AMPERES

Fig. 10 — Heat distribution and metal yield as functions of arc current.

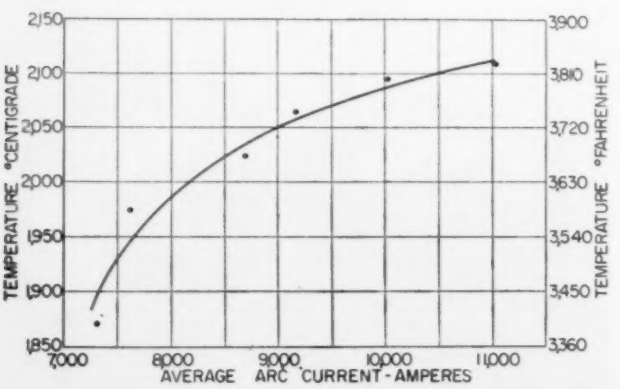

Fig. 11 — Temperature of poured metal as a function of arc current.

Some effects of arc-current variation are presented in Fig. 10 and 11. These graphs should be associated with operating data of Table 4. Although the efficiency of operation reached a maximum at some optimum current near 10,000 amps, the temperature of molten metal continued to increase at higher currents. It has been recognized for some time in direct current arc welding with a consumable rod[8], and in production of simple ingots by consumable-electrode arc-melting that the melting rate is directly proportional to arc current.

This is also true of consumable-electrode arc-casting, but care must be exercised in defining melting rate. In arc-melting of ingots, which does not involve a skull in the normal sense, the melting rate is the same as the rate of electrode consumption. Skulls are involved in arc casting. It was found that any loss of weight by a skull must be added to electrode consumption to yield a melting rate proportional to arc current.

In cases of weight gain by a skull, the increase represents metal acquired from the electrode and is already included in the electrode consumption rate. The ratio of melting rate to current in the experiments under discussion was about 1.2 lb/min/kilo/amp. No ordered dependence of temperatures or operating efficiencies on arc power was discovered. The influ-

TABLE 4 — VARIABLE ARC CURRENT SERIES OPERATING DATA*

Heat No.	Nominal Intended Current, amp	Ave. Recorded Current, amp	Power, kw	Energy, kw min	Ave. Pressure, Microns	Wt. Poured, lb	Residual Skull Wt., lb
SA 17299	8,000	7,320	256.9	4,329	142	157.8	114.9
SA 17285	9,000	7,620	248.4	4,784	292	181.9	106.7
SA 17230	10,000	8,700	288.0	4,693	119	191.7	80.7
SA 17469	11,000	9,188	312.4	4,498	160	179.8	74.1
SA 17397**	11,000	10,017	347.6	4,953	126	137.9	55.8
SA 17604	12,000	11,039	415.1	5,769	89	193.8	115.8

* Ti-6Al,4V alloy; 11-in. ladle
** No initial skull

TABLE 5 — VARIABLE PRESSURE SERIES, OPERATING DATA*

Heat No.	Nominal Intended Current, amp	Ave. Recorded Current, amp	Power, kw	Energy, kw min	Ave. Pressure	Wt. Poured, lb	Residual Skull Wt., lb
SA 17604	12,000	11,039	415.1	5,769	89 micron	193.8	115.8
SA 17469	11,000	9,188	312.4	4,498	160 micron	179.8	74.1
SA 17540	11,000	11,200	364.0	5,533	164 mm	162.6	97.5
SA 17563	11,000	10,133	347.6	5,526	527 mm	145.3	106.7

* Ti-6Al,4V alloy; 11-in. ladle.

TABLE 6 — VARIABLE LADLE SIZE SERIES, OPERATING DATA*

Heat, No.	Ladle Diameter, in.	Ave. Recorded Current, amp	Power, kw	Energy, kw min	Ave. Pressure, Microns	Wt. Poured lb	Residual Skull Wt., lb
SA 17774	8-1/2	10,062	361.2	3,395	91	104.7	70.1
SA 17469	11	9,188	312.4	4,498	160	179.8	74.1
SA 17604	11	11,039	415.1	5,769	89	193.8	115.8
SA 17653	14-1/2	10,387	353.2	4,203	101	135.2	90.4

* Ti-6Al,4V alloy

TABLE 7 — VARIABLE ALLOY SERIES, OPERATING DATA

Heat, No.	Alloy	Ladle Diam., in.	Ave. Recorded Current, amp	Power, kw	Energy, kw min	Ave. Pressure, Microns	Wt. Poured, lb	Residual Skull Wt., lb
SA 17397*	Ti-6Al,4V	11	10,017	347.6	4,953	126	137.9	55.8
SA 17774	Ti-6Al,4V	8-1/2	10,062	361.2	3,395	91	104.7	70.1
SA 17798	Ti	11	10,160	364.7	4,650	166	125.0	57.8
SA 18011*	Ti-4Al,4Mn	8-1/2	8,710	292.7	3,746	121	39.0	83.6
SA 18066*	Ti-8Mn	8-1/2	9,310	301.6	2,413	190	28.0	36.6
SA 18080*	Ti-8Mn	8-1/2	9,420	319.3	4,566	133	58.9	114.0

* No initial skull

ence of current was independent of electrical potential.

Ladles of different sizes were used with results shown in Fig. 12 and 13. Since only three ladle sizes were available for use, it is difficult to draw conclusions. However, it appears that there were optimum operating conditions that resulted in maximum efficiency while the trend of molten metal temperature increased as the ladle diameter decreased.

A trend toward lower operating efficiencies at higher furnace pressures is indicated by Fig. 14. Interpretation is handicapped by a shortage of information, but molten metal temperatures did not seem seriously affected by pressure changes. Values of 3831F (2110 C), 3750F (2065 C), 3759F (2070 C), and 3840F (2115 C) were calculated at pressures of 89 microns, 160 microns, 164 mm, and 527 mm, respectively.

Results for the various alloys available are compared in Table 8. Probably the most significant facts inferred by these data are that molten metal temperatures were generally higher and operating efficiencies were lower for alloys containing manganese. On the basis of previous routine experience the lower efficiencies were expected. It had been assumed that the reason for this was an excessive loss of heat by vaporization of manganese.

The existence of higher temperatures and the pressure levels maintained (Table 7) completely contradict this notion. It now appears that the explanation of lower efficiencies in the case of manganese alloys goes much deeper, and involves a basic influence of manganese on the arc discharge mechanisms.

The temperatures of skull metal were remarkably uniform throughout, regardless of operating conditions. Variations were random, and could not be related to operating conditions. Calculated values ranged from 2523F-3002F (1385 C-1650 C), and averaged 2731F (1500 C). The one 3002F (1650 C) value was obtained with commercially pure titanium. This is probably too high since the melting point is only 3020F (1660 C). The estimated error for all reported metal temperatures is ± 90F (± 50 C).

The similarity between the fraction of the total charge poured and the fraction of total heat contained by molten metal is shown in Fig. 10, 12, and 14. Although this seems perfectly logical, it could not be anticipated. The heat content of molten metal must certainly depend to some extent on the volume or mass of molten metal, but not necessarily on the fraction of total charge represented by that mass. The similarity does not represent a cause and effect relationship. Comparison of the three graphs reveals that a given yield does not always correspond to the same portion of heat in molten metal.

The heat lost during arc operation, and not appearing in either cast metal or the residual skull, varied widely from about 30 per cent to 70 per cent of the total heat input. However, the manner in which direct heat losses were dissipated was fairly consistent. Of this direct loss, 80-88 per cent was included in the heat content of cooling water from the ladle. Another 10-20 per cent represented heat generated in water-cooled electrode components. This includes friction brushes used to apply power to the stinger shaft.

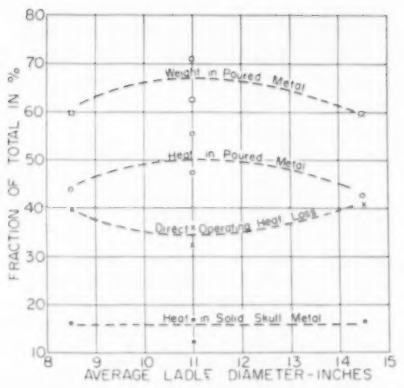
FRACTION OF TOTAL IN %
Weight in Poured Metal
Heat in Poured Metal
Direct Operating Heat Loss
Heat in Solid Skull Metal
AVERAGE LADLE DIAMETER-INCHES

Fig. 12 — Heat distribution and metal yield as functions of ladle diameter.

TABLE 8 — VARIABLE ALLOY SERIES, RESULTS

Heat, No.	Alloy	Melting Rate, lb/min	Molten Metal, Temp.	Skull, Temp.	Fraction of Total Charge Poured, %	Fraction of Heat in Molten Metal, %	Fraction of Heat in Skull, %	Direct Operating Heat Loss, %
SA 17397	Ti-6Al,4V	13.2	3805 F (2095 C)	2779 F (1525 C)	71.3	39.06	9.0	52.0
SA 17774	Ti-6Al,4V	11.9	3849 F (2120 C)	2760 F (1515 C)	59.9	43.8	16.3	39.9
SA 17798	Ti	13.7	4342 F (2395 C)	3002 F (1650 C)	68.4	40.8	10.3	48.9
SA 18011	Ti-4Al,4Mn	9.9	4425 F (2440 C)	2589 F (1420 C)	31.8	16.5	16.7	66.8
SA 18066	Ti-8Mn	7.2	4460 F (2460 C)	2930 F (1610 C)	43.3	18.1	12.4	69.5
SA 18080	Ti-8Mn	11.5	4139 F (2280 C)	2617 F (1435 C)	34.1	19.0	18.4	62.6

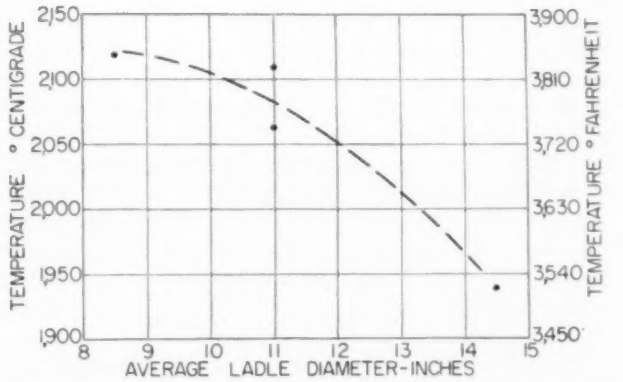

Fig. 13 — Temperature of poured metal as a function of ladle diameter.

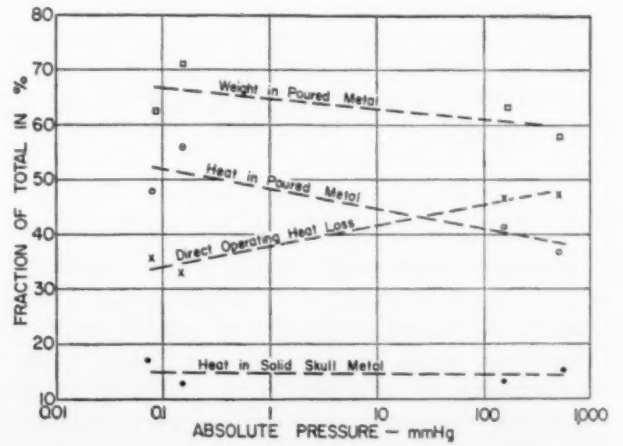
FRACTION OF TOTAL IN %
Weight in Poured Metal
Heat in Poured Metal
Direct Operating Heat Loss
Heat in Solid Skull Metal
ABSOLUTE PRESSURE — mmHg

Fig. 14 — Heat distribution and metal yield as functions of furnace pressure.

TABLE 9 – CARBON ANALYSES OF SURFACE SAMPLES (0.005 IN. DEEP) FROM AS-CAST CUBES, DISPLAYED ACCORDING TO CUBE SIZE AND CUBE FACE

Cube Face	Test Cube Sizes					
	8 in.	6 in.	4 in.	2 in.	1 in.	Ave.
Top	643ppm	467ppm	788ppm	635ppm	923ppm	691ppm
Front[1]	447ppm	583ppm	525ppm	572ppm	1038ppm	633ppm
Sides	652ppm	635ppm	585ppm	639ppm	619ppm	626ppm
Rear[2]	855ppm	547ppm	750ppm	867ppm	1695ppm	907ppm
Bottom	480ppm	973ppm	678ppm	588ppm	1403ppm	824ppm
Ave.	615ppm	641ppm	629ppm	660ppm	1136ppm	736ppm

Note: Values for 6- and 8-in. sizes represent an ave. of 3 cubes, values for 2- and 4-in. sizes represent an ave. of 6 cubes, and values for the 1-in. size represent an ave. of 4 cubes.

[1] Cube face opposite the rear.

[2] Cube face through which metal was gated into the cube.

TABLE 10 – CARBON ANALYSES OF SURFACE SAMPLES (0.005 IN. DEEP) FROM AS-CAST CUBES, DISPLAYED ACCORDING TO CUBE SIZE AND MOLD MATERIAL

Cube Size, In.	Machined Graphite	Rammed Graphite
4	635 ppm	2625 ppm
2	785 ppm	1408 ppm
1	972 ppm	3548 ppm
ave.	797 ppm	2527 ppm
average of 1- to 4-in. sizes from Table 9.	808 ppm	----

Less than one per cent appeared as miscellaneous losses through furnace walls.

Unfortunately, complete evaluation of the castings produced as part of the experimentation described above is laborious and time consuming. Consequently, full information is not yet available, but results of a cursory analysis of reactions between molten metal and molds appear in Tables 9 and 10. No ordered correlations were detectable between the degree of mold reaction and the various operating variables that influenced metal temperatures. Cubes cast under a variety of operating conditions were lumped together for the purposes of the tabulations.

The only pronounced implication to be drawn from Table 9 is that the 1-in. molds were more susceptible than the larger sizes to attack by molten metal. This is believed a consequence of a washing action that is encouraged by the small dimensions.

In larger molds the force of metal flowing in is dissipated over surface areas that are larger and more remote from the point of metal entry. Table 10 shows that the surfaces of cubes cast in rammed graphite molds are sufficiently contaminated to have low corrosion resistance. Sand blasting and pickling of such castings should readily expose corrosion-resistant metal. Typical analyses for carbon in the melting stock used to produce the cubes ranged between 100 and 200 ppm.

CONCLUSION

Consumable-electrode, cold-mold arc-casting in a vacuum has been demonstrated to be a practical method of processing reactive metals. The technique is adaptable to the production of special shapes by either static or centrifugal casting. In some instances this provides the only means of satisfying requirements for corrosion resistance, alloy homogeneity, high temperature strength, or special nuclear properties.

The practice should not be considered competitive with vacuum-induction casting, levitation melting, or electron-gun melting. These methods supplement each other yielding a broad range of processes capable of satisfying a broad range of requirements.

As currently practiced, arc casting is not without limitations. To date, metal or alloys melting above about 4175F (2300 C) have not been cast. Costs are relatively high (about $12.00 per lb from sponge casting for titanium). There is room for improvement in mold designs. Other methods of improving product soundness need to be explored.

The electrical efficiency of the technique is surprisingly high approaching 60 per cent when a 10,000-amp current is used to melt titanium in an 11-in. ladle at a superficial pressure near 100 microns. The best means for estimation and control of pouring temperatures appears to be accurate measurement and control of arc current. An integrating amp/min meter might be advantageous.

In considering applicability of the process to a specific metal, the possible influence of the metal, an alloy additive, or an impurity on arc mechanisms must be taken into account along with melting point, vapor pressure, and reactivity. The choice of a mold material depends on the chemical properties of the molten metal being cast, and the use intended for the casting. Relatively high-surface contamination may be tolerable in many applications. It is conceivable that a carbided or oxidized surface could be of advantage in some instances where abrasion or local heating are factors.

ACKNOWLEDGEMENT

The cooperation of Westinghouse Electric Co., E. I. du Pont de Nemours, Chase Brass and Copper Co., Frankfort Arsenal, and Kolcast Industries, in specific phases of work is acknowledged.

REFERENCES

1. R. A. Beall, F. W. Wood, J. O. Borg, and H. L. Gilbert, "Production of Titanium Castings", Bureau of Mines Report of Investigations 5265, 42pp, August 1956.
2. S. J. Noesen, "The Removal of Gaseous Impurities by Vacuum Arc Melting", General Electric Research Laboratory Report No. 58-RL-1899, February, 1958, 18pp.
3. H. Gruber, "Survey of European Arc Furnaces", Lecture No. 8, New York University Vacuum Metallurgy Course, June 10-14, 1957. Publication pending in *Vacuum Metallurgy* Reinhold Publishing Corp., New York.
4. F. W. Wood and R. P. Adams, "Molds for Titanium Casting," *Light Metal Age, Vol.* 15, *nos.* 7 & 8, August 1957, pp 18-20.
5. A. L. Feild, Jr., "Expendable Molds for Titanium Castings," *Metal Progress, Vol.* 70, *no.* 4, October 1956, pp 92-96.
6. L. B. Golden, I. R. Lane, Jr., and W. L. Acherman, "Embrittlement of Zirconium and Titanium in Hydrochloric Acid," *Industrial and Engineering Chemistry, Vol.* 45, *no.* 4, April 1953, pp 782-786.
7. A. W. Klein, "Evaluation of Cast Extension Brackets," Westinghouse Electric Co. Report WAPD-NCE-3156, January 5, 1957.
8. J. L. Wilson, G. E. Clausen, and C. E. Jackson, "The Effect of I^2R Heating On Electrode Melting Rate," *Welding Journal, Vol.* 35, *no.* 1, January 1956, pp 1s-8s

GAS PRESSURES IN GREEN SAND MOLD

By
C. T. Marek* and C. B. Ward**

A culmination of intensive experimentation on sand characteristics has all but eliminated the typical blow due to gas evolution from the sand. Success in this achievement can be attributed to development of synthetic sands and to analytical methods associated with empirical controls. Much data in recent years have been compiled, furnishing invaluable aid to the technician in modifying sand characteristics and predicting results for casting production.

The purpose of this study was to investigate the fundamental nature of this type of blow phenomenon, with an expectation that through better understanding of its nature, a more basic approach to sand technology may evolve. A logical analysis was pursued by first recognizing the basic components that affect the activities of the process followed by an evalution of theories concerning their interactions. Theoretical and speculative deductions were then verified with experimental conclusions.

THEORETICAL CONSIDERATION

Mold pressure may be created by confinement of steam. Its intensity is dependent on moisture content and flow of heat through sand. Whether a mold blows or not, depends on two factors: 1) the rate of generation of steam at the time metal is molten, and 2) the flow characteristics of the confined vapor through sand. A certain pressure must be developed to force a blow, and this pressure can be achieved only if there is sufficient capacity to generate the gas and confine it at the time that metal is still molten. Therefore, this problem resolves itself to an investigation of the flow of both heat and gas through molding sands. Moisture in this problem is the principal independent variable.

When molten metal comes to rest in a mold cavity its superheat is practically exhausted and primary precipitation is in progress. Moisture in the sand adjacent to the metal will immediately vaporize, creating a pressure which under normal conditions is less than the hydrostatic pressure of the metal. This initiates a system of events which continues under an ever-changing situation of variables.

Almost immediately a mold-metal interface is developed, creating considerable temperature drop between the heat source and the sand, which has the heat absorbing body. At some specific moment there exists three simultaneous thermal arrests. The solidification reaction rejects heat, supplying energy to the vaporization zone, which, in turn, provides the ambient heat in the area where the vapor condenses again. The pressure differential created in the vaporization zone causes vapor to flow through the specimen. As soon as the vapor reaches a temperature below 212 F, it condenses and the heat of reaction is rejected into the ambience. Thus, water vapor is the chief medium by which heat is distributed through the green portion of the mold. As soon as a part of the specimen reaches a temperature of 212 F, it ceases to be a heat absorbing body. It then functions as a transmittal medium to promote passage of vapor to a more distant condensation zone.

To recapitulate, there are four areas or zones in the sand system which are continually changing in position and possibly in length. They are illustrated in Fig. 1 and are described as follows.

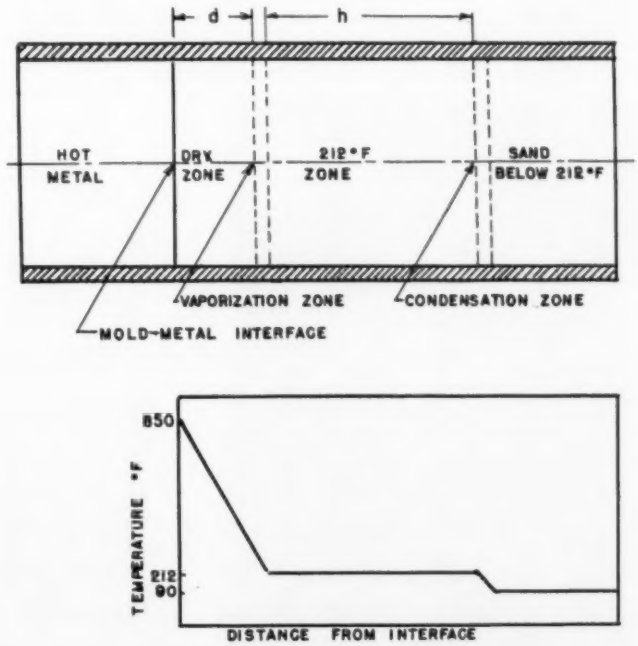

Fig. 1—Sectional view of experimental mold. Bottom view shows changes in temperature of various sand zones.

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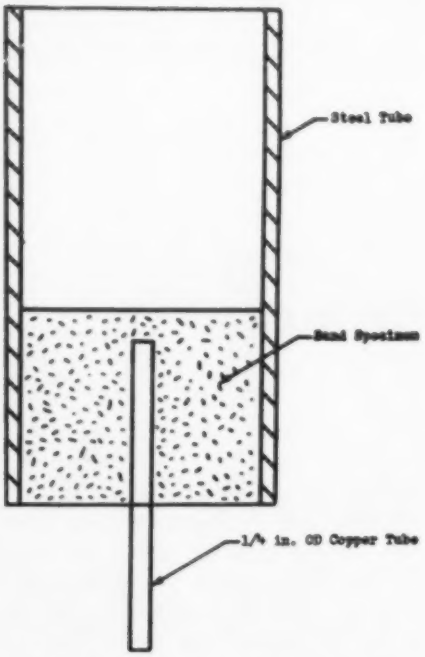


Fig. 2—Left—Specimen holder.

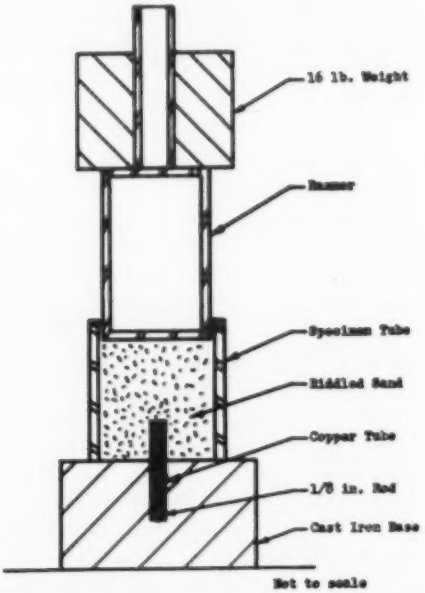


Fig. 3—Right—Ramming apparatus.

1. The dry zone adjacent to the mold-metal interface increases in depth as a result of moisture vaporization. Its rate of increase is dependent on the conductivity of dry sand, temperature of the metal, and moisture content of the green sand.
2. The vaporization zone is a narrow section which moves ahead of the dry-sand, generating vapor as it progresses.
3. The 212 F zone continually changes in length and position. One end of the 212 F zone degenerates as it is consumed by the vaporization zone, the other end grows as moisture is deposited. Its rate of growth is dependent on the specific heat of green sand, its density, and the degrees of temperature below 212 F.
4. The condensation zone is similar to that of the vaporization zone, except the reverse function is performed. A temperature rise is accompanied with an increase in moisture content.

EXPERIMENTAL METHOD

Since permeability and pressure are both functions of moisture content, it was necessary to consider them simultaneously. Pressure was correlated with time for consideration of rate changes, and moisture was chosen as the control variable of the experiment. This constituted the first part of the procedure. The second part determined temperature gradients in the mold at various time intervals. All the castings were sectioned, and attempts were made to correlate experimental data with the observed blow cavities.

Pressure Measurement. In the preliminary work of this investigation, it was observed that the highest gas pressure in molding sands exists beneath the mold cavity in the drag. An attempt, therefore, was made to design an experiment that would simulate the typical mold. The flask (specimen holder) for this experiment consisted of a steel tube 3 in. diameter and 6 in. long as shown in Fig. 2. Molten metal was poured into the top of the tube to produce heating of the sand in a manner similar to the bottom of a mold cavity.

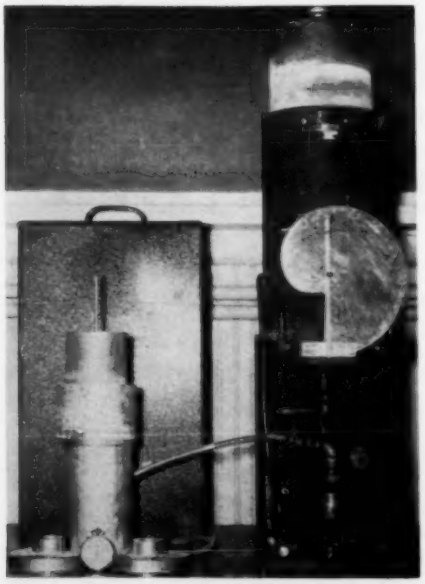


Fig. 4—Modified permeability tester.

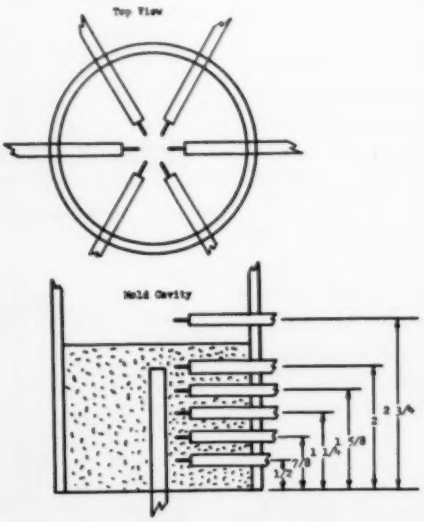


Fig. 5—Thermocouple positions in specimen tube.

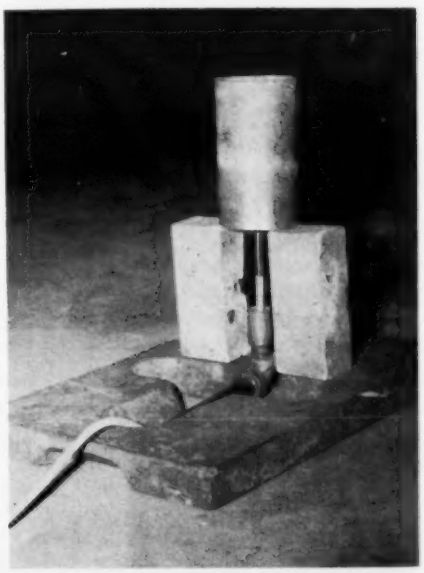


Fig. 6—Specimen tube showing pressure tube and support blocks.

The procedure in ramming the specimen was according to AFS recommendations, except that the weight of the rammer was changed to obtain the same degree of compaction as the smaller 2 in. standard specimen. Derivation of the size of weight and height of fall are given in Appendix A. Figure 3 shows the ramming apparatus and illustrates the procedure. A modified permeability tester shown in Fig. 4 was used to determine the as-rammed permeability of the mold.

A 1/4-in. O.D. by 5 in. long copper tube was rammed in the specimen for mold pressure determinations. An inclined water manometer, registering one in. of water pressure per 4-5/8-in. length of inclined manometer tube, was connected to the copper tube in the specimen with rubber tubing.

Temperature Measurement. A regular specimen tube, altered with six 3/16-in. diameter holes to admit thermocouples for temperature gradient determinations was prepared as shown in Fig. 5. One of the thermocouples was placed near the mold-metal interface in the mold cavity to determine metal temperatures at that level. The remaining five chromel-alumel thermocouples were located in the sand at intervals of 3/8-in. from the mold-metal interface.

The thermocouples were connected to a multiple-record strip chart recorder which recorded one temperature every two sec, thus recording the temperature at one level every 12 sec. The chart speed was set at 60 in. per hr.

Pressure Measurements. Experiments were performed on a non-ferrous, naturally bonded molding sand of the following properties.

Dry density—98.5 lb per cu ft
Optimum green strength—14.3 psi at 5.4 per cent moisture
Optimum permeability—35 at 4.4 per cent moisture
AFS grain fineness—129
Grain distribution

Mesh No.	Retained on Screen, %	Mesh No.	Retained on Screen, %
6	0.2	100	15.0
12	0.2	140	21.6
20	0.2	200	19.6
30	0.2	270	7.8
40	0.4	Pan	8.3
50	1.2	Clay	20.0
70	5.3		

Enough sand for the entire investigation was separated from the foundry sand system and mulled as a single batch for 6 hr to thoroughly mix the sand and clay particles. It was then stored in a steel cart and removed to the sand laboratory to reduce the possibility of gravity segregation and contamination. At the start of each day's experimentation, a small amount of sand was prepared to the desired moisture content in a laboratory muller. After mulling it was riddled through a 25 holes per sq in. riddle, placed in one-gallon jars, and allowed to set for one hr to promote bonding stability and homogeneity. Four tests of a given moisture content were available from a single batch contained in two jars.

After a one-hr lapse, the moisture content was again determined, and enough sand was riddled through a 144-holes per sq in. riddle for a test specimen. In the ramming procedure, a 1/8-in. diameter rod was inserted in the copper tube to prevent sand from entering the tube. Ramming was performed by dropping a 16 lb weight, three times from a height of 3.9 in. The pressure tube which extended to 3/8-in. of the mold-metal interface was then cleared by removal of the 1/8-in. diameter rod.

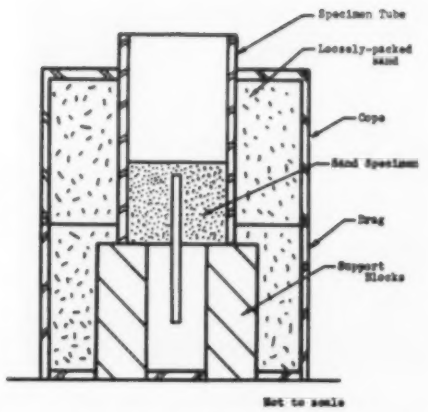


Fig. 7 — Right — Pressure test specimen ready for pouring.

The permeability test according to the AFS formula, $P = \frac{Vh}{pat}$, consisted of passing 2000 cc of air through a 2 in. high specimen with a 7.06 in.^{2} area. Permeability numbers were presented in the customary c.g.s. units, namely $\frac{cm^4}{min\ gm}$.

Following the permeability test and a hardness check, the manometer connection of rubber tubing was carefully made, and the assembly was supported on two iron blocks as shown in Fig. 6. A bench flask was placed around the specimen tube and filled with loosely packed molding sand, as shown in Fig. 7, to insulate the specimen from heat losses. Figure 8 shows the assembly as it stands ready to be poured.

The metal used was an aluminum casting alloy with an analysis of 5% Si, 1.3% Cu, 0.5% Mg, and the remainder Al. Its liquidus temperature is 1160 F, and the solidus temperature is 1050 F. The metal was poured at 1360 F.

As soon as the specimen tube was filled to the top with molten metal, an aluminum cylinder 2-3/4-in. diameter by 6 in. long was inserted in the tube to chill the top surface of the metal. This provided a gastight seal on the top of the specimen tube and prevented mold gas from bubbling out through the metal. Figure 9 shows the test after it had been poured.

Pressure readings at regular intervals of time were recorded as soon as pouring began, and were continued until a maximum value was passed. Typical

Fig. 8 — Specimen tube in flask-pressure test.

Fig. 9 — Pressure test after pouring.

pressure-time plots are shown in Fig. 10. Readings were taken at 5-sec intervals and recorded by checking off the manometer height of graph paper placed behind the manometer tube.

Temperature Measurements. The specimen tube containing six holes for thermocouples was prepared by jolting the sand twice, inserting the thermocouples, and finally applying the third jolt. The pressure tube was retained in the specimen to duplicate heat transfer conditions existing under the pressure measuring setup. Obviously, the permeability of this specimen could not be measured since the holes for the thermocouples allowed air to escape. The specimen tube was then carefully packed in the center of the flask as shown in Fig. 11. Extra precautions were taken so

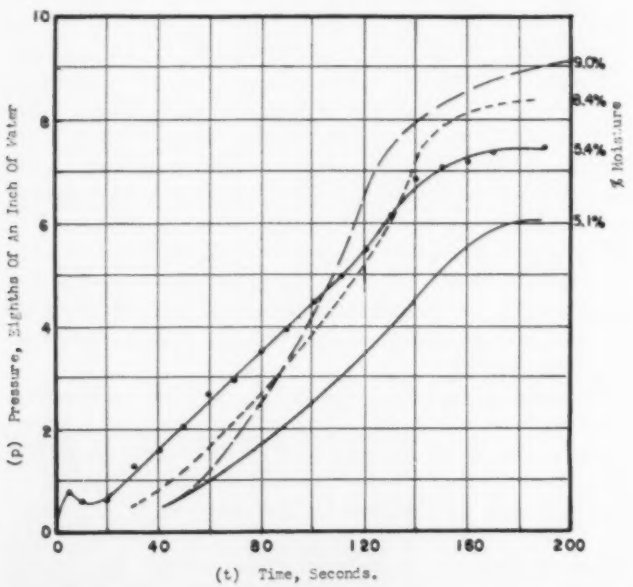


Fig. 10—Typical plots of pressure vs. time for sand moisture contents.

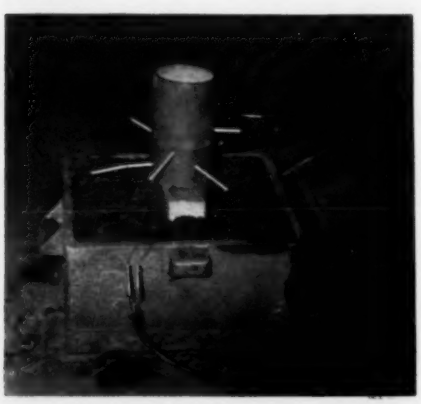


Fig. 11 — Specimen tube for temperature test.

that none of the thermocouples shorted out on the metal flask.

Connectors were used to complete the circuit to the recorder, and the mold was ready to be poured, as shown in Fig. 12. The mold was poured and plugged as in previous practice, and 6-position temperature gradients were obtained at regular time intervals.

RESULTS AND CONCLUSIONS

Pressure measurements and their relationship to moisture and permeability are tabulated in Table 1, and illustrated graphically in Figs. 13, 14 and 15. Where more than one test was made on a given batch, the data are plotted as an arithmetical average.

In the determination of the effect of moisture on maximum mold pressure, it was apparent during the early periods of experimentations that a disrupting uncontrolled factor was in operation. It was also observed that this disturbance was greatest at moisture contents in excess of 7 per cent when casting indentations (referred to as blows) began to appear.

In fact, the size of the blow hole appeared to have a direct relationship to the observed maximum pressure. At a given moisture content, the larger the blow cavity, the lower was the observed pressure. This seems reasonable since the blow cavity produces a larger confined volume for a given amount of vapor. Since the volume of the blow cavity was different in each test, reproducibility of pressure data was poor. However, it seemed apparent that measured maximum pressures varied inversely with the size of the blow cavity.

Fig. 12—Temperature test ready for pouring.

TABLE 1 — AVERAGE BATCH PROPERTIES

Sand Batch	Moisture, %	As-rammed Permeability	Maximum Pressure ⅛-in. H_2O
1	5.1	52.9	7.3
2	5.4	59.0	7.2
3	6.1	58.6	7.8
4	7.0	54.8	8.5
5	7.0	56.0	7.7
6	7.8	46.0	8.2
7	8.3	43.0	9.94
8	8.4	47.0	8.3
9	9.2	42.1	9.3
10	10.5	28.0	Metal blew out of mold

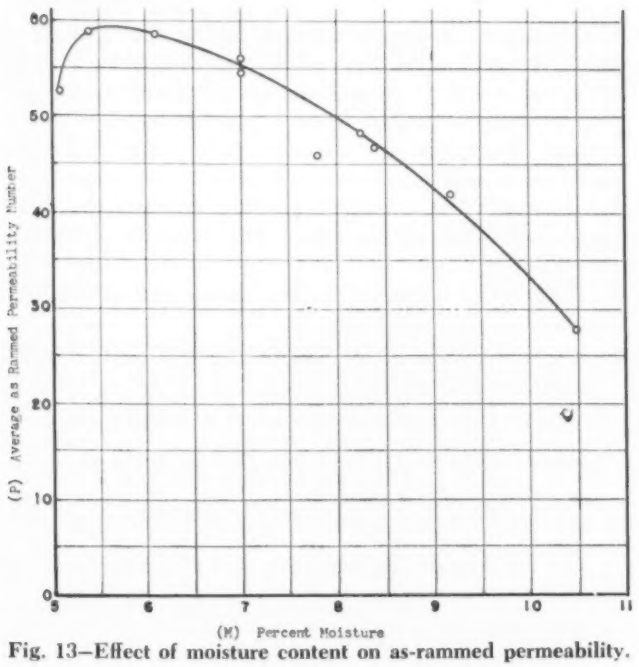


Fig. 13—Effect of moisture content on as-rammed permeability.

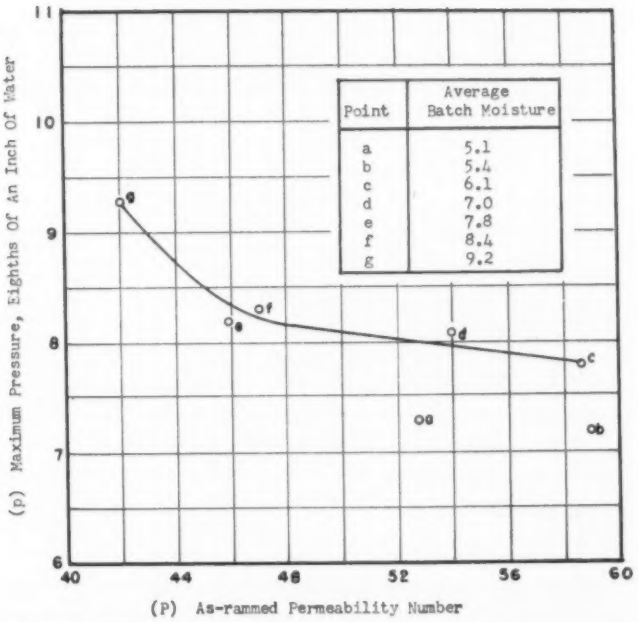


Fig. 14—Effect of permeability on maximum mold gas pressure.

As would be expected, Fig. 14 confirms the fact that mold pressures decrease with increasing permeability. Since permeability is a function of moisture content, as represented in Fig. 13, it is obvious that changes in permeability up to an optimun of 5.5 per cent moisture tend to counteract (reduce) the pressure-producing effect of vapor generation. With increasing moisture content beyond this optimum value, the opposite is true; a decreasing permeability promotes an increasing pressure.

It is logical to assume, therefore, that this additive pressure effect would be noticeable in experimental results. This becomes apparent on the graph of Fig. 14 in the neighborhood of 7.8 per cent moisture. It is of interest to note that points *a* and *b* are on the upward slope of the moisture-permeability graph and therefore do not coordinate with the illustrated curve.

At 10.5 per cent moisture a severe blow was produced which blew most of the molten metal out of the specimen tube. Needless to say, such a situation is dangerous, and precautionary measures were taken to protect the researchers from injury. A metal hood was placed over the specimen tube about 16 in. above the mold to prevent molten metal from shooting high into the air. This hood proved an effective safety device.

A typical time-temperature-distance from mold-metal interface relationship is shown in Fig. 16. This illustrates the rate of heating of the sand specimen. As has been confirmed by others[7], the rate of heat extraction was approximately the same for all moisture contents tested. Figure 17 shows the rate of movement of the interface between the 212 F zone and the evaporation.

In considering what took place inside a specimen tube under blow conditions, it appeared that the effect of three different mechanisms had to be correlated: 1) the vaporization and subsequent condensa-

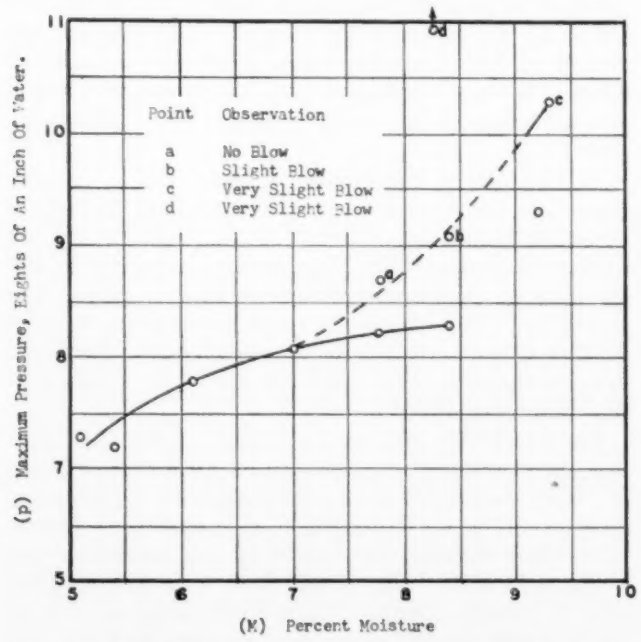

Point Observation
a No Blow
b Slight Blow
c Very Slight Blow
d Very Slight Blow
(p) Maximum Pressure, Eighths Of An Inch Of Water.
(M) Percent Moisture

Fig. 15—Effect of moisture content on maximum mold gas pressure.

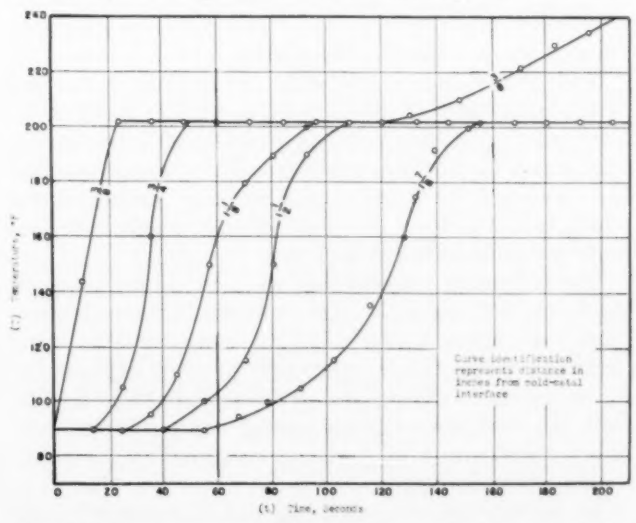


Fig. 16—Time-temperature-distance from interface for sand of 5.4 per cent moisture content.

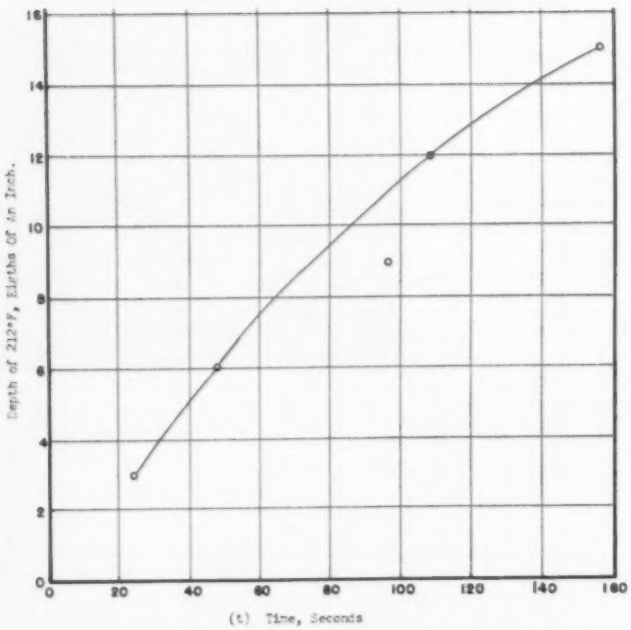


Fig. 17—Depth of sand at 212F vs time for a sand of 5.4 per cent moisture.

tion of moisture, 2) the formation of a blow cavity, and 3) the effect of internal shrinkage in the metal.

As molten metal enters the mold some moisture immediately flashes into steam, producing a pressure build-up which is proportional to the inability of sand to exhaust gases. Under certain conditions this pressure build-up may be sufficient to push the partially solidified metal upward, forming blow cavities of various design as illustrated in Appendix B. As metal continues to solidify, internal shrinkage occurs. Since the solidifying metal is contained in an airtight shell, a vacuum is created inside the casting which will tend to pull the partially solidified metal of the side wall inward.

It is a highly speculative point as to how much, if any, internal vacuum correlates with mold pressure in the disfigurement of the casting bottom. There is not much question as to the mechanism of a typical blow which causes metal and gas to spurt out of the sprue of the mold. This type of a blow occurs within seconds after the time the mold is poured, and vacuum has no effect on the system.

If mold pressure is not sufficient to blow metal out of the mold and a thin skin forms at the mold-metal interface, a delicate balance may exist between the opposite sides of the membrane. The vacuum partially overcomes the gravitational force of molten metal which bears against one side of the membrane, and mold pressure on the other side.

The following calculations were made to compare the values of conductivity and permeability with commonly accepted values, and to compare computed pressures with those observed in the experiment. Since the open end of the pressure tube was 3/8-in. from the mold-metal interface, all computations were based on the time of 2 min, corresponding to a dry-sand specimen depth of 3/8-in.

To reduce space-consuming details, various units such as densities, specific heat, etc., are converted into convenient dimensions in Appendix C.

Growth of Zones. A comparison of the growth of the 212 zone with that of the dry-sand zone, provides an excellent perspective of the basic mechanism underlying the mold pressure phenomenon. The following derivation is based on the theory that the heat consumed in vaporizing moisture in one zone, becomes available again in a cooler zone where vapor condenses back to moisture. For zone designations, refer to Fig. 1.

a) Heat (Q_d) required to evaporate moisture in the d zone.

$Q_d = A\ d\ \rho\ M\ H_g = 7.06 \times 0.375 \times 0.060 \times 0.054 \times 970 = 8.33$ BTU

where A = 7.06 in.^{2} (area), d = 0.375 (length of dry-sand zone), $\rho = 0.060 \frac{\text{lb}}{\text{in.}^3}$ (density of sand), $M = 0.054 \frac{\text{lb } H_2O}{\text{lb sand}}$ (moisture content) $H_g = 970 \frac{\text{BTU}}{\text{lb}}$ (heat of vaporization at 212F and 14.7 psi)

b) Heat (Q_h) absorbed per in. of green sand to raise its temperature from 90F to 212F.

$Q_h = V\rho C_p(\Delta T) = 7.06 \times 0.060 \times 0.234 \times (212\text{-}90) = 12.1 \frac{\text{BTU}}{\text{in.of specimen}}$

Where V = 7.06 in.^{3} (Volume of 1 in. of specimen), ρ = 0.060 lb/in.^{3} (density of sand), C_p = 0.234 BTU/lb/F (specific heat of green sand), ΔT = (212 - 90)F (temperature rise in sand)

c) Length (h) of 212F zone when the d zone is ⅜-in. long. h = item b/item a = 8.33/12.1 = 0.692-in.

d) Ratio of growth of h zone to d zone = 0.692/0.375 = 1.84

The significant feature of this derivation points out the principal mechanism by which heat is transferred in green sand. To elucidate on this point we may consider water as the carrier of heat. Its capacity is principally the heat of vaporization, and its velocity of flow is directly related to the pressure potential and inversely proportional to frictional resistances. The theoretical growth of the h zone being 1.84 times as great as the d zone, signifies a steadily increasing length of the h zone. It follows therefore that resistance to flow of vapor increases with time, and this is accompanied by an increasing pressure and decreasing flow.

In the actual experiment it was found that the growth of the h zone was more rapid than theoretical calculations indicate, the ratio being 3.34 as compared to the theoretical 1.84. No attempt was made to isolate and to experiment with various side effects that would influence the more rapid movement. A small portion of this effect may be attributed to heat conduction through the h zone, promoted by a temperature difference of (212 – 90) F.

Another likely influence is based on the possibility that the condensation zone may not be a cross sectional plane, perpendicular to the specimen axis. Irregularity could be attributed to the possibility of greater vapor flow through the center of the specimen than at the side walls. This would lead to a condensation zone of similar contour. Thus, the volume of sand at 212 F could be the same as that computed, but the zone extending along the center line where the thermocouples were located, would indicate a longer h

zone. Also the effect of conductivity through flask walls lessens the effect on condensation in the sand adjacent to the flask.

Conductivity of Sand. As a matter of confirming the reliability of this experiment it is of interest to determine the conductivity of dry sand in the *d* zone, on the basis of experimental results. It is also of interest to compare this value with published and generally accepted values of sand conductivity.

The movement of the dry zone being 3/8-in. in 2 min or 11.25 in./hr, the average amount of heat being consumed in vaporizing moisture is as given below.

$Q = A\ R\ \rho\ M\ H_g = 7.06 \times 11.25 \times 0.060 \times 0.054 \times 970 = 250$ Btu/hr

Where

$A = 7.06$ in.^{2} (area of specimen)

$R = 11.25$ in./hr (rate of movement of d zone),

$\rho = 0.060$ lb/in.^{3} (density of sand)

$M = 0.054$ lb H_2O/lb sand (moisture content)

$H_g = 970$ BTU/lb H_2O (heat of vaporization of water)

The conductivity (k) of sand based on experimental values is computed from the basic heat flow formula $Q = A\ k\ \Delta T/x$

$$k = \frac{Qx}{A\Delta T} = 250 \times \frac{0.037}{12} \times \frac{1}{0.049} \times \frac{1}{638}$$

$= 0.0250$ BTU/ft hr F

Where

$Q = 250$ BTU/hr (heat consumed in evaporating moisture), $x = 0.375/12$ ft (length of d zone), $A = 0.049$ ft^2 (area of specimen), $\Delta T = 638$F (Temperature gradient 850 - 212)

A thermal conductivity of 0.250 BTU/ft hr F is a reasonable value which compares favorably with published values. For example a 20-30 sand described by Paschkis[7] and others, has a conductivity value of 0.133 at 212 F. At 850 F the conductivity rises to 0.270 BTU/ft hr F. The mean conductivity is 0.199 BTU/ft hr F.

Permeability. Using experimental data, it is possible to speculate on permeability limits in the "h" zone as they actually exist under operating conditions. On the premise that the "h" zone is the calculated length of 0.692 in., permeability computations may be made with the formula $q = AP\ \Delta p/h$.

$$P = \frac{qh}{A\Delta p} = 200 \times 0.692 \times \frac{0.0918}{7.06} \times 0.0248 =$$

72.4 cm^4/min gm

Where

$P =$ in.^{4}/min lb (permeability)

$q = 200$ in.^{3}/min (average rate of vapor generated, see Appendix C)

$h = 0.692$ in. (length of 212F zone)

0.0918 = conversion factor to the cm-gram system. (See Appendix C)

$A = 7.06$ in.^{2} (area of specimen)

$\Delta p = 0.248$ lb/in.^{2} (experimental gage pressure at 3/8-in. from interface and 120 sec).

The permeability of 72.4 should be interpreted as the minimum value that would be required to permit an average flow rate of 200 cu in. per min of vapor to flow through the *h* zone. Under these conditions pressure would remain constant, and a steady state flow would exist. A steadily rising pressure, however, indicates that the existing permeability of the sand is incapable of maintaining equilibrium.

The as-rammed permeability value of 58 indicates a deficiency in permeability. Therefore, as is confirmed by experiment, pressure should rise. The addition of moisture to the *h* zone by deposition of water through condensation, tends to reduce the as-rammed permeability and to contribute toward an increasing pressure rise.

CONCLUSION

The authors are cognizant that there were many side activities which influenced the system under investigation, and that there is considerable need for refinement, both in the experimental and theoretical approach. However, despite the lack of consideration of unsteady state conditions, it is apparent and interesting to note that reasonable answers and fair correlations are available.

No doubt there are many compensating errors, as might be found in the consideration of permeability. Because of the difference in viscosity and density of water vapor, its flow characteristics may be somewhat better than that of air. However, because of the deposition of moisture in the *h* zone, the passage of gas through the sand medium becomes more difficult. The degree of cancellation of one factor over the other has not been determined and must await further investigation.

Although much progress has been made in understanding processes through empirical investigations, one might find it stimulating and quite advantageous to venture into the theoretical aspects when searching for solutions for various phenomena.

REFERENCES

1. C. Locke and R. L. Ashbrook, "Nature of Mold Cavity Gases", A.F.S. Transactions, *V 58*, p. 584, 1950.
2. Foundry Sand Testing Handbook, pp. 14, 20-26, American Foundrymen's Society, Des Plaines, Ill. (1944).
3. H. W. Dietert, H. H. Fairfield, and F. S. Brewster, "Surface Gas Pressure of Molding Sands and Cores", Transactions AFS, *V 56*, p. 528, 1948.
4. W. M. Saunders, Sr. and W. M. Saunders, Jr., "Effect of Heat on the Permeability of Natural Molding Sands", Transactions AFS, *V 38*, p. 259, 1930.
5. A. M. Portevin, "Gases and Naturally Occurring Blowholes in Foundry Practice", Transactions AFS, *V 60*, p. 109, 1952.
6. V. Paschkis, "Heat Flow in Sand", Transactions AFS, *V 59*, p. 382, 1951.
7. V. Paschkis, "Heat Flow in Moist Sand", Transactions AFS, *V 60*, p. 163, 1952.
8. C. F. Lucks, O. L. Linebrink, and K. L. Johnson, "Thermal Conductivities of Three Sands", Transactions AFS, *V 55*, p. 62, 1947.
9. F. A. Brandt, H. F. Bishop, and W. S. Pellini, "Solidification of Various Metals in Sand and Chill Molds", Transactions AFS, *V 62*, p. 646, 1954.
10. V. Paschkis, "Influence of Dry Sand Conductivity on Rate of Freezing of Steel Slabs", Transactions AFS, *V 58* p. 147, 1950.
11. R. Schuhmann, Jr., *Metallurgical Engineering Principles*, Cambridge, Addison-Wesley Press, 1952, 191-99.

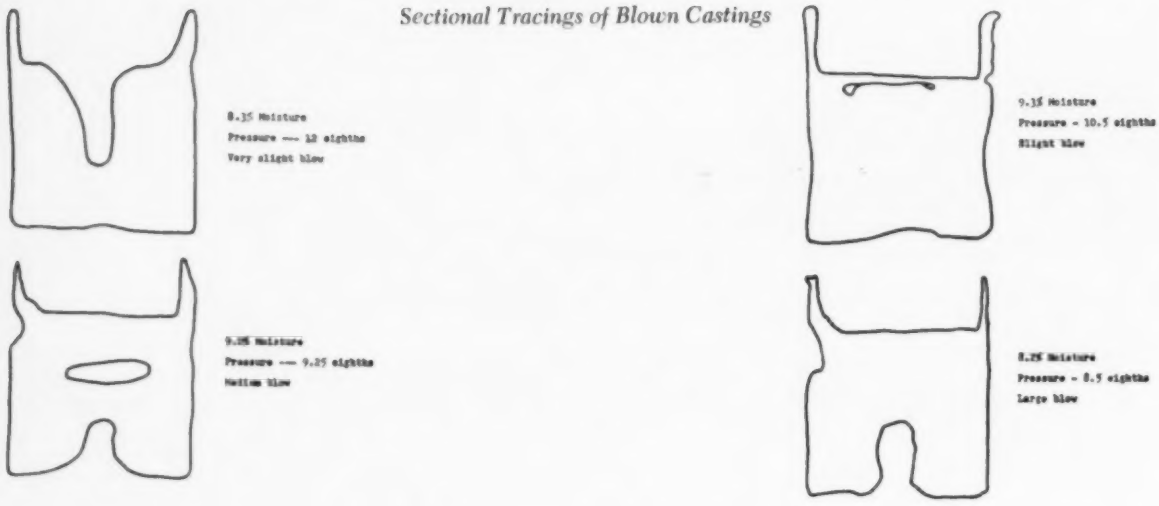
APPENDIX A

Calculation of Compaction Energy of Experimental Rammer

A. Compaction energy of standard AFS rammer: Three 2 in. drops of a 14-lb weight. Specimen

APPENDIX B

Sectional Tracings of Blown Castings



diameter is 2 in.
14 lb × 2 in. = 28 in.-lb/drop
28 in.-lb/πsq in. = 8.92 in.-lb/sq in.

B. Compaction energy of experimental rammer:
Three ? in. drops of a 16-lb weight. Specimen diameter is 3 in.
$(1.5)^2\pi$ sq in. = 7.07 sq in.
8.92 in.-lb/sq in. × 7.07 sq in. = 63 in. lb
63 in.-lb/16 lb = 3.93 in.
Need three 3.93 in. drops of the 16-lb weight.

APPENDIX C

Units and Designations

(A) Area of specimen
$A = \pi(3)^2/4 = 7.06$ in.^{2} or 0.049 ft^2

(ρ) Density of sand
$\rho = 27.3$ g/in.^{3} or 0.06 lb/in.^{3}

(H) Heat of vaporization of water at 14.7 psi and 212F
Hg = 970 BTU/lb

(C_p) Specific heat of sand at 90F and 5.4 per cent moisture. Reference (6)
C_p = [0.054 lb H_2O/lb green sand × 1 Btu/lb H_2O] + [(1-0.054) lb dry sand/lb green sand × 0.19 BTU/lb dry sand] = 0.234 BTU/lb

(V) Volume per in. of specimen
V = 7.06 in.^{3}/in. or 0.00407 ft^3/in.

(Δp) Gage pressure (above atmosphere)
Δp = 1 in. H_2O or 0.0361 lb/in.^{2}

(v) Specific volume of steam at 14.7 psi and 212F
v = 26.82 ft^3/lb or 46,500 in.^{3}/lb

(P) Permeability
P = 1 in.^{4}/lb min = 0.0918 cm^4/min gm

(q) Average rate of steam generated in dry zone
$q = Ad\rho Mv/t = 7.06 \times 0.375 \times 0.060 \times 0.054 \times 46500/2 = 200$ in.^{3}/min

Where
A = 7.06 in.^{2} (area)
d = 0.375 in. (length of dry sand zone at 120 sec)
ρ = 0.060 lb/in.^{3} (density of sand)
M = 0.054 lb H_2O/lb sand (moisture in sand)
v = 46,500 in.^{3}/lb (specific volume of steam)
t = 2 min (time for dry sand zone to reach ⅜-in. length).

APPENDIX D — EXPERIMENTAL PRESSURE DATA

% Moisture	As-rammed Permeability	Maximum Pressure (⅛-in. H_2O)	Remarks
5.1	56.0	6.4	
5.1	53.5	7.7	
5.1	49.4	7.8	
5.4	60.0	7.0	
5.4	58.5	7.3	
5.4	58.5	7.4	
6.1	58.5	7.8	
6.1	59.5	8.3	
7.0	57.0	7.2	
7.0	53.3	8.7	
7.0	54.0	9.5	
7.0	55.3	7.5	
7.0	58.5	7.7	
7.0	54.2	8.0	
7.8	46.0	7.6	Medium blow cavity
7.8	45.4	8.2	Small blow cavity
7.8	46.5	8.7	No blow cavity
8.3	50.6	16.5	Slight blow cavity
8.3	46.4	8.4	Large blow cavity
8.3	46.4	8.0	Medium blow cavity
8.3	46.6	9.1	Slight blow cavity
8.3	48.2	7.7	Medium blow cavity
9.1	35.7	8.3	Large blow cavity
9.1	41.6	10.3	Slight blow cavity
9.1	43.6	9.3	Medium blow cavity
9.1	47.3	9.1	Large blow cavity
10.5	28	No casting — metal blown out of mold	

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Technical Research

Committee 8-J Conducts Work Week to Obtain Data for Further Study

Committee 8-J, Physical Properties of Iron Foundry Molding Materials at Elevated Temperatures, recently conducted a work week at the University of Wisconsin, Madison, Wis.

The committee conducted experiments on veining tendencies with the results to be examined by statistical methods in an attempt to isolate the primary causes of veining.

Each member of the committee, headed by Chairman J. A. Gitzen, devoted at least three days to the five-day work week conducted in the University's Department of Mining & Metallurgy. Committee members did the actual work of conducting the experiments as shown in the pictures.

Previously the committee had studied scabbing in gray iron castings. Work on this project was done at the University of Michigan, Ann Arbor, Mich., and at the University of Wisconsin.

The committee's work is typical of AFS technical division activities. Hundreds of valuable man-hours are contributed by experts in the specific fields of castings technology. After considerable experimental work followed by lengthy investigation and study, reports are published either in MODERN CASTINGS or presented at the Annual AFS Convention.

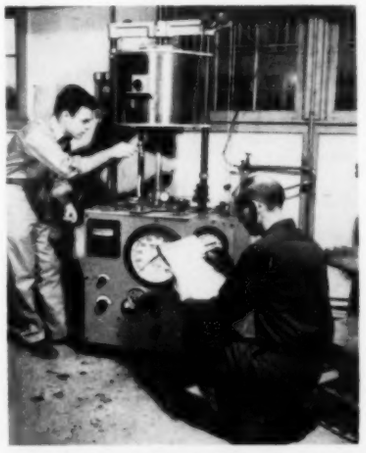
Prior to the meeting each member

Continued on page 96

available to the entire foundry industry.

In the near future a complete progress report will be prepared by Committee 8-J and will be made available to the AFS membership

Committee 8-J proves that research is not all theoretical. Left to right are: Chairman J. A. Gitzen, Delta Oil Products Co., Milwaukee; Eugene J. Passman, Frederic B. Stevens, Inc., Detroit; Richard A. Green, Westlake, Ohio; A. H. Zrimsek, Magnet Barium Corp., Des Plaines, Ill.; Jay S. Groh, Manley Sand Co., Rockton, Ill.; Carl R. Loper, Jr., University of Wisconsin; Victor Rowell, Harry W. Dietert Co., Detroit; Arthur E. Murton, Department of Mines & Technical Surveys, Ottawa, Ont., Canada; Edward C. Zuppan, Bendix Aviation Corp., Lake Shore Division, St. Joseph, Mich.; Charles E. Morrison, Ironton, Ohio; John Lemon, Ford Motor Co., Dearborn, Mich.



A. H. Zrimsek (left) and Charles E. Morrison running test on hot compression strength testing machine at 8-J Committee meeting held at University of Wisconsin.

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NEWS and VIEWS

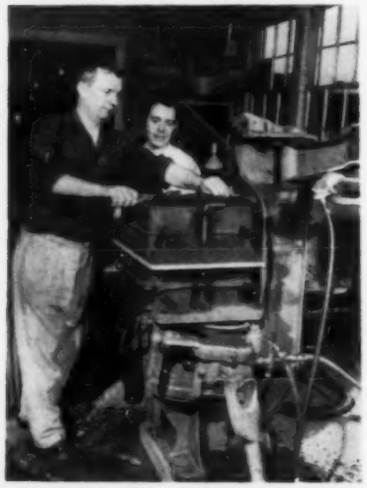
National News

Technical Research

Continued from page 95

was given an analysis report showing the various types of metals used at the last work meeting held at the University of Wisconsin. Members were also given a copy of revised procedures for determination of restraining loads and determination of shock-load expansion tests.

Committeemen were asked to review the revised procedures for adoption as a tentative standard.



Jay S. Groh (left) and Edward C. Zuppan shown striking off the mold for tests conducted by Committee 8-J.

T&RI Adds New Course

■ Scheduling of an Advanced Industrial Engineering course at the Marquette University Management Center, Milwaukee, has been announced by S. C. Massari, Director of the AFS Training & Research Institute. The course will deal with sampling, rating practices and quality control.

A total of 11 courses remain to be presented in the 1958 T&RI courses. Among the subjects are Cupola Melting of Iron, Sand Control Technology, Patternmaking, Industrial Environment, Metallography of Non-Ferrous Metals, Product Development, Air Pollution Control & Legislation, Industrial Engineering, Gating & Risering of Ferrous Castings, and Foundry Plant Layout.

Most of the courses have not been presented previously. They have been added to the curriculum as a result of requests by those attending for a broader coverage of the industry.

Hungarian Foundry Relics Said to be 1700 Years Old

■ Remnants of tools and crucibles of an iron foundry estimated by archeologists to be 1700-years old have been unearthed at Tokod according to an Associated Press story originating in Budapest.

Tennessee Chapter's out-going Chairman F. Frank Anderson (3d from left) surrenders gavel to W. L. Austin. Others are newly elected officers: Vice-Chairman Charles E. Seman; Treasurer James W. Richie; Secretary Frank M. Robbins, Jr.

1958 T&RI Courses

Cupola Melting of Iron — **July 7-11—Chicago**

Lecture course for cupola operators, supervisors, metallurgists and foremen. Basic principles for optimum cupola operation are considered. Registration fee $65.

Sand Control Technology* — **Aug. 11-15—Detroit**

Lecture course for foundrymen having had some experience in sand testing control and technology. Pre-requisite; Sand Testing course or equivalent experience. Registration fee $65.

Patternmaking — **Aug. 18-20—Chicago**

Lecture and demonstration. Course for patternmakers, foremen, supervisors, trainees, purchasers of castings, suppliers and management. Registration fee $40.

Industrial Environment — **Sept. 8-12—Chicago**

Demonstration and lecture course on in-plant environmental problems and safety. Appropriate for foremen, supervisors, engineers, safety men and top management. Registration fee $65.

Metallography of Non-Ferrous Metals* — **Sept. 15-17—Chicago**

Lecture course for melters, supervisors, foremen, foundry engineers, researchers, laboratory technicians, metallurgists and design engineers. Registration fee $40.

Product Development — **Sept. 24-26—Chicago**

Lecture course on product analysis from design to marketing of finished castings. Scheduled for foundry engineers, sales engineers, technicians, supervisors, metallurgists and management. Registration fee $40.

Air Pollution Control & Legislation — **Oct. 1-3—Chicago**

Lecture course covering the laws and interpretation, problems, suggested solutions and the drafting of ordinances from the foundry standpoint. Registration fee $40.

Industrial Engineering — **Oct. 13-17—Milwaukee**

Lecture and work shop course on better standards and cost control. Rating and motions and time-study techniques. Registration fee $125.

Gating & Risering of Ferrous Castings — **Oct. 27-31—Chicago**

Lecture course on the problems relating to gating and risering. Intended for foremen, technicians, foundry engineers, supervisors, industrial engineers and production and quality control personnel. Fee $65.

Advanced Industrial Engineering — **Nov. 3-7—Milwaukee**

Work sampling, rating practices, quality control including uses of motion pictures in these phases. Registration fee $125.

Foundry Plant Layout — **Nov. 10-12—Chicago**

Lecture course on problems of rehabilitation or building of new plants. Intended for foremen, supervisors, industrial and production engineers and management. Registration fee $40.

*Courses originally scheduled for other dates.

Payment of tuition fees should accompany enrollment application. Make reservations only with Director, AFS Training & Research Institute, Golf & Wolf Roads, Des Plaines, Ill. Tel. VAnderbilt 4-0181.

Outstanding Foundrymen Assemble at Annual AFS Alumni Dinner

Ninety-five members of the AFS Alumni Group attended the Annual Dinner held during the 62d Castings Congress & Foundry Show.

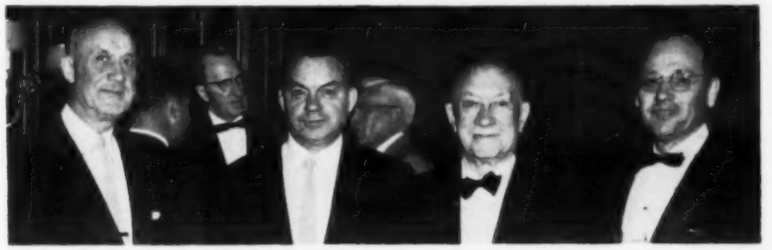
The Alumni Group consists of persons who have served as Officers or Directors of the Society, as well as Gold Medalists, winners of Awards of Scientific Merit and Service Citations and Honorary Life Members. At the present time the group is composed of slightly more than 200 members.

Alumni Dinners are held to maintain friendly relationships established during the terms of office or service and to aid the Board of Directors in promoting the objectives of the Society.

The first meeting was held in Cleveland during the 1916 Convention. Since then Alumni Dinners have been an established custom with the last Past President acting as the presiding officer.

Alabama was represented by **L. H. Durdin** (Director Class 1957, current AFS President); **Lester N. Shannon** (Director Class 1939, President 1940-41); **Thomas H. Benners, Jr.** (Director Class 1951); **Charles K. Donoho,** (Simpson Medalist 1957).

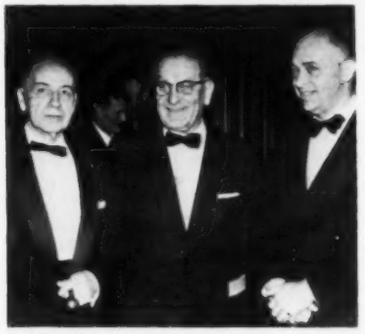
Attending Alumni Dinner left to right: **Peter E. Rentschler** (Simpson Medalist 1948); **Hyman Bornstein** (Director Class of 1935, President 1937-38, McFadden Medalist 1946, Chairman T&RI Trustees 1957-1859); **Bruce L. Simpson,** (Director Class 1949, President 1955-56); **Stowell C. Wasson,** (Director Class 1949); **Fred J. Walls** (Director Class 1942, President 1945-46); **Richard A. Flinn** (Simpson Medalist 1947).



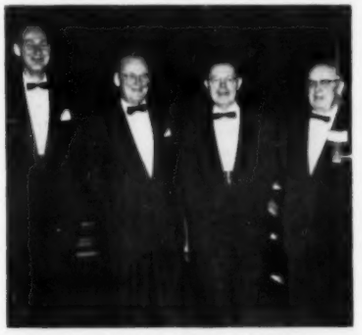
Left to right are **Frank C. Riecks** (Director Class 1950, Honorary Life Member 1955); **Donald J. Reese** (Whiting Medalist 1941); **Gulliam H. Clamer** (Director Class 1917, President 1923-24, Seaman Medalist 1933); **Harry W. Dietert** (McFadden Medalist 1940; Director Class 1954; President 1957-58).

Former President **Frank W. Shipley** (Director Class 1953, President 1956-57); talks with **Clyde A. Sanders** (Whiting Medalist 1957; Director Class 1961); and former AFS President **Frank J. Dost.**

Texan **Jake Dee** (Director Class 1961) flanked by Californians **Robert Gregg** (Director Class 1948, 1951) and **John R. Russo,** (Director Class 1960).



Ralph J. Teetor (Director Class 1936, President 1944-45); **William D. Dunn,** (Director Class 1960) and **Fred J. Pfarr** (Director Class 1960).



Jovial group includes **Karl L. Landgrebe, Jr.** (Director Class 1960); **James H. Smith** (Director Class 1948, Simpson Medalist 1953); Prof. **James Hayes,** guest speaker; **Dan M. Avey** (Director Class 1934; President, 2 terms 1934-1936).

Frank J. Dost (Director Class 1947, President 1954-55); **Walter E. Sicha,** (McFadden Medalist 1954); **Earl M. Strick** (Honorary Life Member 1954); **LeRoy P. Robinson** (Director Class 1943, Honorary Life Member 1954); **Roger W. Griswold** (Director Class 1959). Dost, Sicha and Robinson were former Chairman of the Northeastern Ohio Chapter.

Japanese foundry management team shown at 62d Castings Congress & Foundry Show. Team on 6-week study of foundry organization and management visited AFS headquarters in June. The 13-man team was composed of two labor representatives and management personnel from small and medium sized foundries. Included in the team were Junichi Takeyama, Shiegekichi Aikawa, Tyuzaburo Harada, Susumu Haswgawa, Yasuo Imai, Kyioshi Kakehi, Tadakazu Komamura, Makoto Koseki, Kenichi Maekawa, Yasuhiko Ota, Wasaburo Sugihara, Tejiro Takashaski, Harunosuke Takatsuki.

Hard Work Pays Off at Cleveland for Apprentices

First place Apprentice Contest winners receive awards at AFS Annual Business Meeting. Left to right: **Adam J. Kravetz** (Wood Patternmaking) Progress Pattern Co., Pontiac, Mich.; **Paul Niebur** (Metal Patternmaking) Central Pattern Co., St. Louis; **Raymond McDermott** (Gray Iron Molding) Brown & Sharpe Mfg. Co., Providence, R. I.; **James E. Gift, Jr.** (Steel Molding) Dodge Steel Co., Philadelphia; **William Boatright** (Non-Ferrous Molding) AiResearch Mfg. Co., Los Angeles.

Second place winners in AFS Apprentice Contest. **Clifford Duckworth** (Metal Patternmaking) Caterpillar Tractor Co., Peoria, Ill.; **James Sanders** (Gray Iron Molding) Fairbanks, Morse & Co., Beloit, Wis.; **James Rogers** (Steel Molding) Oregon Steel Foundry Co., Portland, Ore.; **L. Thomas** (Non-Ferrous Molding) AiResearch Mfg. Co., Los Angeles. **Gerald Celk** (Wood Patternmaking) **John C. Beuse Patterson,** Los Angeles, was unable to attend.

Apprentice Contest winners were displayed at the AFS Foundry Show. Inspecting the exhibit are former AFS President **Frank W. Shipley,** Caterpillar Tractor Co., Peoria, Ill., and Apprentice Contest Committee Vice-Chairman **G. E. Garvey,** Garvey Pattern & Mfg. Co., South Bend, Ind.

Chapter News

Mexico Chapter Assists in Advancing Technical Data

■ Mexico Chapter's 1958-59 technical program consisting of 14 subjects has been developed to assist in that country's efforts in placing greater emphasis on the dissemination of technical information and in-plant training of personnel.

The February meeting featured a discussion of Mexican heavy industry. "Copper and Copper Alloys" were discussed in April.

Patricio Qunitanilla, Tezuitlan Copper Co., emphasized the rapid growth during the past few years in the iron, steel and chemical industries. Among the main points in future plans will be increased production of high-quality steel, increased production and decreased imports of rolled products, and stimulation of technical training for employees.

He suggested that the iron and steel industry should exploit markets calling for use of highly alloyed steels and that the industry should assist in organizing and disseminating basic technical information.

Roberto Tapia Reyes, Cobre y Aleasiones S.A. addressed the Chapter in April on "Copper and Copper Alloys."—*Jose A. Perez Casas*

Participating in the **Mexico Chapter** April meeting were Juan de Luca, Metales Avila SA; Chapter Secretary Enrique Leon Andrade; Chapter Vice-President Luis Delgado Vega; Chapter Education Officer Fernando Gonzalez Vargas; and speaker Roberto Tapia Reyes.

View of part of audience at **Mexico Chapter's** April meeting. Greater increases in the dissemination of technical information is part of Mexico's program in the basic heavy industries.

Past Chairmen of the **Central Ohio Chapter** were awarded certificates of appreciation at the May meeting. In front row are: Kenneth McGrath (1944-45) Alten Foundry & Machine Co., Lancaster, Ohio; Thomas E. Barlow (1945-46) International Minerals & Chemicals Corp., Chicago; Norman H. Dunbeck (1946-47) International Minerals & Chemical Corp., Chicago; Ray Frank (1947-48) Bonney-Floyd Co., Columbus, Ohio; Fred W. Fuller (1948-49) Fred W. Fuller Co., Cleveland; William T. Bland (1950-51) Commercial Steel Castings Co., Marion, Ohio. Rear row: Daniel F. Krause (1952-53) Gray Iron Research Institute, Columbus, Ohio; C. W. Gilchrist (1953-54) Cooper-Bessemer Corp., Mt. Vernon, Ohio; Ray Meyer (1954-55) Ohio Steel Foundry Co. Springfield, Ohio; Naaman H. Keyser (1955-56) Battelle Memorial Institute, Columbus, Ohio; Thomas W. Cusack (1956-57) O. S. Kelley Co., Springfield, Ohio; Paul Eubanks (1957-58) Ohio Steel Foundry Co., Springfield, Ohio. —*Jose Acebo*

Attending **New England's** May Meeting was this delegation from Draper Corp. including AFS Director H. G. Stenberg and speaker Earl Harlow, second and third from left.

Mo-Kan Chapter

Introduce Officers

■ Certificates of appreciation were awarded to officers serving during the 1957-58 season at the May meeting. New officers were also introduced. No technical speaker was scheduled for the meeting but two films were shown, "Iron-Carbon Alloys" and "Pressure Cast Matchplates."—*J. T. Schlanker*

Metropolitan Chapter

Sand Process Talk

■ Flow charts were used by O. J. Myers, Reichhold Chemicals, Inc., White Plains, N. Y. in addressing the April meeting. Myers discussed various sand processes classifying binders into organic and inorganic groups and their components. He also discussed the advantages and disadvantages of the binders both in combinations and when used separately. —*C. H. Fetzer*

Edwin A. Walcher, Jr., American Steel Foundries, Chicago at the April meeting of the **Northeastern Ohio Chapter** discussed "Building a Modern Foundry Organization." Walcher (left) receives congratulations from Program Chairman A. H. Hinton, Aluminum Co. of America.—***Harold Wheeler***

Texas Chapter

Hears Purchasing Agents

■ A critical review of what purchasing agents look for when buying castings was presented at a recent meeting of the Texas Chapter. Four purchasing agents participated.

D. J. McConnell, National Supply Co., Houston, Texas, stated that he looks for a definite delivery schedule, quality product and an economic price.

Norvell Slay, A.C.F. Industries, Houston, Texas, placed his requirements in this order; quality, delivery.

Jack Edwards, Guiberson Corp. Div., Dresser Industries, Dallas, Texas, stressed good liaison between purchaser and producer and a reasonable profit must be expected by both to insure a satisfactory long-term relationship.

Paul Logan, Convair Div., General Dynamics Corp., Fort Worth, Texas, also served on the panel.

Eastern New York

Holds Joint Meeting

■ Approximately 90 members of the AFS Eastern New York Chapter and the American Society for Metals held a joint meeting in April. J. F. Wallace, professor, Case Institute of Technology, Cleveland, spoke to the group on ductile, gray and malleable irons.

Shown left to right at **Eastern New York's** April meeting are speaker J. F. Wallace, Chapter Chairman L. J. DiNuzzo, General Electric Co., Schenectady, N.Y. and Chapter Vice-Chairman R. N. Williams, George F. Pettinos, Inc., Philadelphia.

Northeastern Ohio Chapter in May held its Recognition Night honoring apprentices, old-timers, former Chapter Chairmen and former National Officers and outgoing officers. Seated at front table are Clem Swencki, A. Ennis, Don Hartman, Al Hinton, John Fintz, Walter Seelbach, E. Claude Jeter, Frank J. Dost, Henry Oehling, Emil Romans, Gorlon Paul, Harold Strater and Larry Rayel. At rear table are Frank Steinebach, Ray Fleig, Jack Tressler, Henry J. Trenkamp, Walter Sicha, Fred Pfarr, Gilbert Nock, Frank Cech, Dave Clark, Alex Barczak.—*H. Wheeler*

Chapter News

Eastern Canada Honors Chapter Authors

Eastern Canada Vice-Chairman Max Reading, (right) Foundry Services (Canada) Ltd., Beaurepaire, Que., presents cash prizes to winners of the chapter's writing contest. Others left to right are A. Cecil, Warden King, Ltd.; M. Daly, Canadian Steel Foundries (1956) Ltd., Montreal, Que.; T. Niven, Canadian Steel Foundries (1956) Ltd., Montreal, Que.; and R. Chamberland, Canada Iron Foundries.—*F. Machin*

A. Cecil (right) winner of the **Eastern Canada** Chapter's writing contest with a paper entitled "The Control of Eutectic Cast Iron." On left is W. Nuttal, Warden King, Ltd., who introduced **Cecil.**

John Hunt (right) Montreal Bronze Ltd., acting for Chapter Chairman Paul Von Colditz, hands over the chapter's gavel to incoming **Eastern Canada** Chapter Chairman Max Reading.

Attending **Eastern New York's** first Ladies Night were left to right at table, National Director W. D. Dunn, Mrs. Louis J. DiNuzzo, Chapter Chairman Louis J. DiNuzzo, speaker R. M. Smith and Mrs. Peter E. Noonan.

Eastern New York

Holds Ladies Night

■ Approximately 100 persons attended the first Ladies Night sponsored by the Eastern New York Chapter. Richard M. Smith, Corning Glass Works, spoke on "Glass and You." Attending as a guest was AFS Director W. D. Dunn, Oberdorfer Foundries, Inc., Syracuse, N. Y.—*Leonard C. Johnson.*

St. Louis Chapter

Core and Mold Blowing

■ Proper use of equipment to facilitate blowing of cores and molds was discussed at the April meeting by L. D. Pridmore, International Molding Machine Co. Pridmore presented an illustrated lecture followed by a discussion period.

More than 250 chapter members and their wives attended the annual April Spring Dance.—*H. V. Boemer*

Varying reactions to what must have been humorous are expressed at **St. Louis** May meeting by Chapter Chairman James A. Cannon, Duncan Foundry & Machine Works, Alton, Ill.; speaker W. G. Gude and Technical Chairman F. J. Boeneker, A.C.F. Industries, St. Louis.

"Security and How to Obtain It" was described at the May meeting of the **Central Ohio Chapter** by Ray Monsalvatge who stated that three needs must be satisfied to attain security. These are physical, emotional and spiritual requirements.—**Jose Acebo**

Saginaw Valley Chapter

Foundry Quality Control

■ An estimated 150 persons in May attended the last regular meeting to hear R. W. Gardner, Ford Motor Co., speak on "Quality Control in the Foundry." Gardner discussed the formulation of a quality control department as well as its authority and responsibility. He also outlined the types of control systems used by Ford and the effectiveness of the program.—*R. J. Gleffe*

New England Chapter

Discusses Foundry Costs

■ Approximately 135 chapter members attended the May meeting featuring a discussion on "Foundry Cost" by Earl Harlow, Draper Corp., Hopedale, Mass. Each member was provided with an actual breakdown of the foundry costs and they determine prices for individual castings.—*F. S. Holway*

Active in **New England's** May meeting were Chapter Chairman Alexander Beck, speaker Earl Harlow and AFS Director Henry G. Stenberg.

Central Indiana

Standardization Program

■ "Standardization and Compliance Programs in the Foundry" were discussed at the May meeting by Austin E. James, Haynes Stellite Co., Kokomo, Ind. R. S. Hodler, Golden Foundry Co., Columbus, Ind., acted as technical chairman.—*W. R. Patrick*

Austin E. James, featured speaker at **Central Indiana** May meeting.

Participating in **Philadelphia's** May meeting were Chapter Chairman H. C. Winte, Speaker William Thomas, Sr., and Technical Chairman H. P. Good—*Leo Houser*

St. Louis Chapter

Future of the Foundry

■ St. Louis Chapter members and members of the University of Missouri School of Mines and Metallurgy at Rolla, Mo., in May, heard W. G. Gude, Penton Publishing Co., Cleveland, speak on "The Future of the Foundry."

The St. Louis Chapter with a membership of less than 300 has averaged 110 men per meeting during current technical season.–*H. V. Boemer*

Deeply involved in a discussion of core and mold blowing at the **St. Louis Chapter** April meeting are H. Bailey, technical chairman, and speaker L. D. Pridmore.

Northeastern Ohio Chapter

Holds Recognition Night

■ Apprentices, old-timers, former Chapter Chairman and National Officers were honored at the chapter's Recognition Night held in May.

Longest service in the foundry industry was held by Henry M. Oehling, formerly of National Malleable & Steel Castings Co., Cleveland, with 72 years.

Apprentices

Wood patternmaking–Edward Lamparyk, Modern Pattern Co., 3d place winner in the national competition; Ronald Zipay, Warner & Swasey Co.; Douglas Petery, Cove Pattern Works.

Metal patternmaking–L. S. Uveges, Ford Motor Co.; Joseph Halm, Cove Pattern Works; H. J. Brown, Ford Motor Co.

Iron molding–Carl Linger and Junior Samples, W. O. Larson Foundry Co.; Joseph Kazimour, Superior Foundry Co.

Non-ferrous molding–Fred Taylor, Harsch-Ebaloy Foundry Co.

Prizes of $25, $15, and $10 were awarded for 1st, 2d, and 3d places with duplicate awards made by the Patternmakers' Association.–*Jack C. Miske*

Central New York

Making Good Castings

■ Closer control of molding sand and the use of cool and fine sands will aid in improving casting quality, Clyde A. Sanders, American Colloid Co., Skokie, Ill., told the chapter at its April meeting. Sanders in an illustrated lecture stressed the methods by which better finishes could be obtained in castings.

Sanders also told foundrymen of his observations made recently on a tour of European foundries.–*C. W. Diehl*

Two AFS Directors attend **Central New York** meeting. On left is Wm. D. Dunn, Oberdorfer Foundries, Inc., Syracuse, N. Y. On right is Clyde A. Sanders, American Colloid Co., Skokie, Ill., featured speaker.

Northern Illinois-Southern Wisconsin

Elects, Officers, Directors

■ Officers and directors for the 1958-59 season have been elected by the Northern Illinois-Southern Wisconsin chapter.

Officers are:

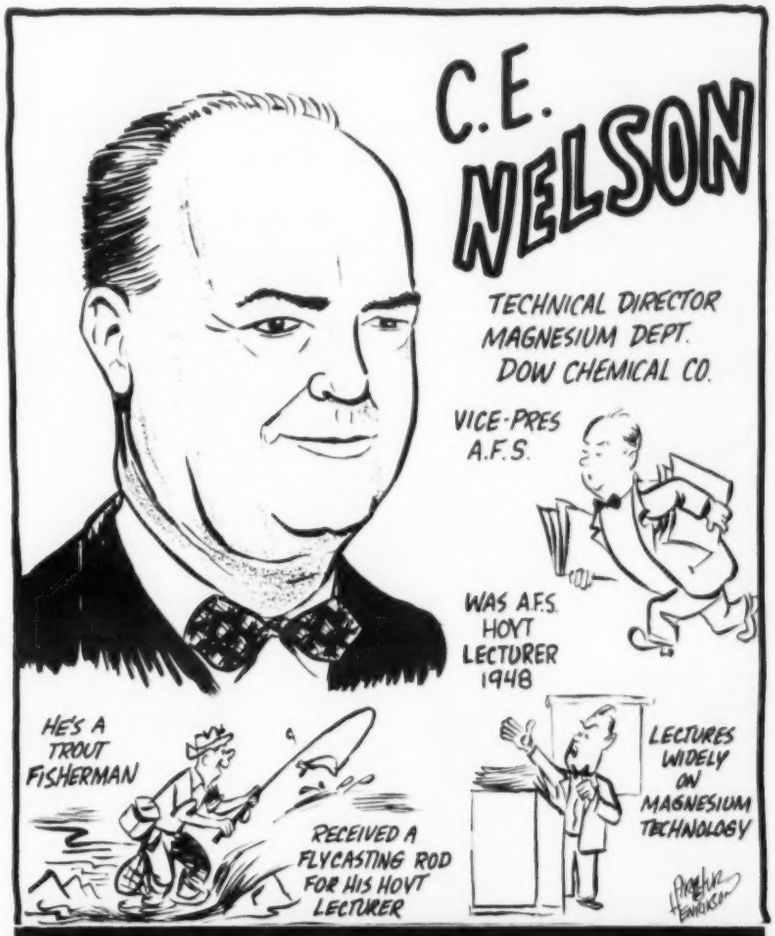
Chairman–Harry V. Rossi, Ebaloy Foundries Corp., Rockford, Ill.

Vice-Chairman–John F. Carberry, Gunite Foundries Corp., Rockford, Ill.

Secretary–George Tamblyn, Greenlee Bros. & Co., Rockford, Ill.

Treasurer–William B. Sterna, Fairbanks, Morse & Co., Beloit, Wis.

Directors (Terms expire 1961) – H. M. Bacon, Beloit Foundry Co., Beloit, Wis.; Roy Ray, Fairbanks, Morse & Co., Beloit, Wis.; John Seeboth, A. P. Green Fire Brick Co., Beloit.


C.E. NELSON
TECHNICAL DIRECTOR MAGNESIUM DEPT. DOW CHEMICAL CO.
VICE-PRES A.F.S.
WAS A.F.S. HOYT LECTURER 1948
HE'S A TROUT FISHERMAN
RECEIVED A FLYCASTING ROD FOR HIS HOYT LECTURER
LECTURES WIDELY ON MAGNESIUM TECHNOLOGY

Personalities

Retiring Wisconsin Chairman N. Amrhein present's chapter's gavel to L. J. Woehlke, new Chapter Chairman. Chapter Secretary B. H. Booth is on right.

C. Fuerst, Falk Corp., Milwaukee, former Wisconsin Chairman, presents retiring Chapter Chairman N. Amhrein with a past president's pin.

Chapter News

Northern California

Hirsch Ends Term

■ Outgoing Chapter Chairman Harold R. Hirsch turned over the symbolic gavel to incoming Chapter Chairman Gordon Martin at the May meeting. Hirsch's concluding business was the awarding of the $100 Andrew Ondreyco award and a special trophy to Conrad Rost, Empire Foundry, as the outstanding apprentice molder.

Approximately 130 members and their ladies attended the May meeting designated as Ladies Night.—*Harold Henderson*

Philadelphia Chapter

What the Customer Wants

■ "What the Customer Wants in His Castings" was explained at the May meeting by William Thomas, Sr., Emmaus Foundry & Machine Co., Emmaus, Pa. Herman P. Good, Textile Machine Works, Reading, Pa., served as Technical Chairman.—*E. C. Klank*

Philadelphia Chapter Chairman (1957-58) H. C. Winte shakes hands with the new Chapter Chairman T. R. Walker. In the center is E. A. Zeeb, new Vice-Chairman.

afs chapter meetings

JULY

Wisconsin . . July 25 . . Tuckaway Country Club . . *Annual Outing.*

Philadelphia . . July 18 . . Manufacturer's Golf and Country Club, Oreland, Pa. . . *Annual Outing.*

AUGUST

Canton District . . Aug. 2 . . Brookside Country Club, Barberton, Ohio . . *Annual Picnic and Golf Party.*

Twin City . . Aug. 18 . . Midland Hills Country Club . . *Annual Golf Outing.*

Final Report on 62d Castings Congress

Continued from page 29

2) There is a family of maximum density distributions.

3) Increased density is possible by increasing the definition (number of screens) in the foundry classification series.

"Density of Sand Grain Fractions of the AFS Sieve Analysis," R. W. Heine, University of Wisconsin, Madison, Wis., and T. W. Seaton, American Silica Sand Co., Ottawa, Ill.

The density of sieve fractions decreases as fineness increases, regardless of the method used for compaction when high-purity silica sand grains are used. The density of sieve fractions increases as fineness decreases, regardless of the method used for compaction.

Presence of iron oxides in sands has the effect of increasing density of the fractions beyond the densities obtained for comparable fractions of relatively pure sands. Regardless of the size and shape of the sand grains, the relationship between compacting energy and density remains the same. This is true of sands relatively free of non-silica particles.

As fineness of the fractions increased, maximum density was achieved with less applied jolting energy. After maximum density was reached, additional application of energy only resulted in a reduction of density of the mass. It was possible to achieve higher densities when the samples were vibrated than could be achieved by either jolting or ramming.

"Correlation of Green Strength, Dry Strength and Mold Hardness of Molding Sands," R. W. Heine, University of Wisconsin, Madison, Wis.; E. H. King and J. S. Schumacher, Hill and Griffith Co., Cincinnati.

Not only does the work of molding vary in the foundry, but so do the sand ingredients, particularly the percentage of water in the sand. Therefore to know the properties of sand in a mold, the green and dry compressive strength properties of molding sands need to be measured over a much wider range of molding effort and mold hardnesses than is now done with the standard AFS "three-ram" test.

This paper shows how green compressive strength and dry compressive strength of foundry sands at various moisture levels are related to the mold hardness developed by molding.

The mold hardness achieved in a particular sand mixture is determined by the ramming effort applied and the moisture content of the sand. A higher moisture content causes a lower mold hardness (and green strength) to be developed from fixed molding energy.

With respect to moisture content, it is the so-called free water which causes the major increase in dry strength and decrease in green strength at any particular clay content. Green strength is maximum in the absence of "free" water and dry strength is very low. The moisture content which should be exceeded for increasing dry strength may be calculated.

"Hot Deformation of Molding Sand," H. W. Dietert, Harry W. Dietert Co., Detroit, and T. E. Barlow, Eastern Clay Products Department, International Minerals & Chemical Corp., Chicago.

The need for hot deformation arises because sand grains grow or expand when heated by molten metal. Hot deformation is one means a sand possesses to accommodate such expansion. Sand grain expansion places the face of a mold in a compressive load. As the load increases the sand mold face will undergo hot deformation, relieving excessive compressive loading. If the sand mold face is unable to relieve the load by deformation, grain growth will build up sufficient compressive stress to buckle the sand mold face.

Sand will expand at a progressive rate; thus one should measure and numerically express the accommodating hot deformation as a rate factor at relative low loads and not at rupture load. The hot deformation rate factor is a possible method for evaluating sands as to their safety factor in reference to mold surface fracture tendencies.

Ultimate hot deformation is useful in evaluating the hot toughness of sand in reference to dirt inclusions, cuts and washes. The hot deformation rate at 2000 F may be increased by the following:

1) addition of cellulose materials,
2) addition of cereal binders,
3) addition of sea coal,
4) addition of pitch,
5) working sand on dry side of temper,
6) working sands with ample clay substance,
7) limiting fines.

"Evaluation of Shell Molding Process Capabilty," W. C. Truckenmiller, C. R. Baker, and G. H. Bascom, Albion Malleable Iron Co., Albion, Mich.

Principal advantage of the shell process for the production of a transmission part was closer dimensional tolerances, which:

1) reduce metal removal,
2) increase ease of static and dynamic balancing,
3) provide greater unimormity desired in automated machining operations.

Statistical analysis of the initial pattern tryout on split differential cases indicated:

1) relationship between the process capability and customer tolerances,
2) provision of an exacting approach to establishment of critical pattern dimensions in a single corrective step without danger of high cost of pattern repair or replacement.

Examples of process capability studies of shell core making equipment showed, as in the cases of casting dimension studies, not only present process capability but indicated numerical values for corrections to improve dimensional accuracy.

"High Temperature Properties of Shell Molds," Report of Sand Division Committee 8-N, R. A. Rabe, Foundry Process Development Section, General Motors Corp., Detroit.

Shells made with bank sand had less severe cracking than those made with an angular grain silica

sand or a round grain silica sand. Test specimens made with the bank sand mixes also had lower hot expansion in the laboratory tests. All shell cracking took place in the first 15 to 60 seconds after pouring.

Shells made with 6 per cent resin, dry mix had less severe cracking and less expansion than the shells made with a 4 per cent resin, cold-coated mix, for a given shell thickness. The plate defect on the cope side of the test casting was entirely eliminated by reducing the gate area from 1.125 $in.^2$ to 0.750 $in.^2$

Castings made in silica sand (round or angular grain) shells had smoother surface finish than those made in the bank sand shells. Castings made in bank sand shells had fewer surface defects due to mold expansion than castings made in silica sand shells.

Because shell molds made with bank sand, containing up to one per cent clay, exhibited less cracking as compared to shells made with washed silica sands, bank sand is recommended where mold cracking is a problem.

"Packing Characteristics of Typical Foundry Sands," L. J. Pedicini, Congress Die Casting Div., Tann Corp., Detroit.

This paper deals with compaction of some typical foundry sand distributions: dry sand, two per cent moisture sand and bonded sands.

The author concludes that:

1) the proper choice of raw sand for green sand molding is much more important than most foundrymen appreciate.

2) more work must be done toward a better understanding of one of the foundry industry's most important raw materials—sand.

"Sodium Silicate for the CO_2 Process," E. A. Lange and R. E. Morey, U. S. Naval Research Laboratory, Washington, D. C.

The rate at which sand mixtures develop strength with CO_2 increases with increase in the SiO_2/Na_2O ratio of the sodium silicate. The maximum gassed strength attained increases with increase in the SiO_2/H_2O ratio of the sodium silicate.

Gassed strength of the sands

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bonded with sodium silicate having high SiO_2/Na_2O ratios is limited because the viscosity of high ratio silicates is sensitive to concentration. Dry strength of sand bonded sodium silicate is dependent upon the composition of the sodium silicate and the CO_2 gassing time.

Humidity of the air during an aging period has a great affect on the strength of sand bonded with sodium silicates. The efficiency of the CO_2 gassing process may be significantly increased by diluting the CO_2 with air.

"Industrial Application of Olivine Aggregate," G. S. Schaller, University of Washington, Seattle.

Compared to silica, the standard foundry aggregate of this country, olivine offers slightly greater cooling effect, increased heat capacity, uniform thermal expansion, resistance to fracture by thermal shock and a somewhat higher fusion point. Since olivine sand is a manufactured aggregate it is available in selected grain sizes that can be controlled and reproduced. The sand grains are angular due to the nature of their manufacture.

In non-ferrous foundries, complete conversion to olivine aggregates has been effective in both product improvement and cost reduction. The use of olivine facing for high manganese-steel castings has shown economic advantages that are so pronounced as to indicate its adoption as standard procedure.

Commercial shell-molding foundries have devised a method of taking advantage of the favorable thermal properties of olivine.

"Sieve Ratios and Processing for Strong Molding Sands," J. T. Parisi, O. C. Nutter and C. Michalowski, Pekay Machine & Engineering Co., Chicago.

Suitably balance of adjacent screen distributions of grain sizes prevents the formation of either rhombohedral or rhombic types of packing. Typically good sands show a repetitive pattern of cubes formed from the mean sizes of adjacent screens.

Strong cubically - compounded structures require three grain sizes for each cube size present to form a supplementary continuous sand network parallel to the cube grain axes. The exceptionally good property Schumacher 4-sieve sand shows 91 per cent of the mass to be tri-cubic structure, with each cube composed of at least three grain sizes.

High strength low - expansion sands compounded cubically from adjacent screens should have less than a 20 per cent volume of the largest cube size. A parallel type of progress for sand preparation is to separate the mixing and mulling phases so greater efficiency and effectiveness can be obtained.

Mixing for greatest effectiveness should be done in two stages. First—pre-mixing in a semi-dry flowable condition, and second—mixing for uniform distribution of temper water and formation of clay films.

The application of full mixing and mulling energies to small successive volume increments permits a high degree of uniformity.

"Sintered Alumina Molds for Investment Casting of Steels," B. Bovarnick, and F. C. Quigley, Watertown Arsenal, Watertown, Mass.

The mold described in this paper offers several desirable features:

1) It is an easily formed thin-walled mold.

2) It has the high refractory qualities necessary for the casting of low alloy steels.

3) It possesses good mechanical strength requiring no backup in casting.

4) There is no evidence of mold metal interaction when casting.

5) The castings produced have good finish and are excellent reproductions of the wax patterns.

6) The process is economically competitive with existing ferrous investment casting methods.

These technical features and economic advantages indicate a high potential for the future use of thin-wall sintered alumina molds.

CO_2 Core Experience in a Malleable Foundry," G. Nestor, National Malleable & Steel Castings Co., Cleveland.

To prevent foundry scrap castings, such as hot tears, blows and cracks, cores are required with low hardness, low gas content and with good collapsibility. It is therefore necessary to consider these prop-

erties when formulating a sodium silicate core-sand mixture. It is also necessary to take into consideration method by which cores are made. The majority of cores are made with a core blower; few are made on the bench or by hand.

From this study it was concluded that cores could be made economically only if quality cores could be produced at a high level of production. To determine if this was possible a high production automotive casting was selected for a trial of the process.

One of the most annoying problems to be overcome was stickiness in the core box directly under the blow holes and on the underface of the blow plate. Another problem was that of hardening of the core-sand mixture in the holes of the blow plate. Hardening of the core sand mixture in the blow chamber or magazine of the core-blow machine was also a major concern.

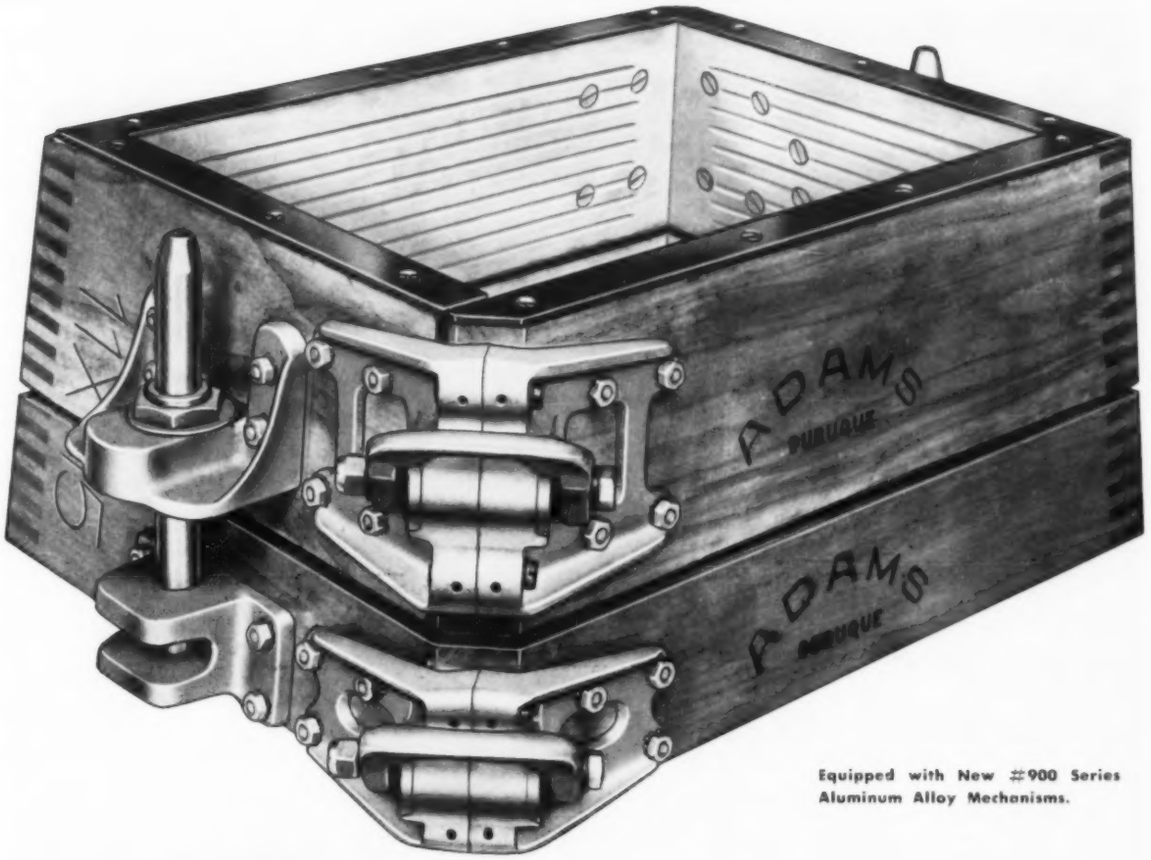
A release oil was added to the core-sand mixture to eliminate these conditions. This release oil was composed of 18 parts fuel oil to one part oleic acid. It was added at the rate of two ounces to every 100 lb of sand mixture. The addition of oil acted as a lubricant as well as a means of retarding air setting of the core-sand mixture before it is used.

"Investigations of the Effect of Heat on the Bonding Properties of Various Bentonites," F. Hofmann, George Fischer Ltd., Schaffhausen, Switzerland.

Various bentonites have different thermal resistances and cannot be fundamentally changed by ion exchange; however, in most cases the rate of bonding capacity loss dependent on temperature may be improved.

Bentonites with high-ion exchangeability have a higher thermal resistance than those with low ion exchangeability. While a high swelling capacity of sodium bentonites is not essential, it indicates a high thermal resistance.

Thermal resistance may be determined by differential thermal analysis (DTA). The position of the second endothermic deflection indicates the temperature of final destruction of bonding power and recovery properties. Bonding capac-



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ity decreases gradually with rising temperature.

Green strength of bentonites as delivered tells little about their life. Bentonites with high initial green strength but poor resistance are less economical than bentonites with moderate bonding capacity but high thermal resistance.

Natural non-swelling calcium bentonites with a high rate of ion exchange may be equivalent to natural western-type bentonites.

"The Problem of Hot Molding Sands," R. W. Heine, University of Wisconsin, Madison, Wis. and E. H. King and J. S. Schumacher, Hill and Griffith Company, Cincinnati.

The hot sand problem of production foundries involves two important physical processes.

First, the sand must be cooled to a temperature where effective mulling begins. The cooling process requires a definite time interval and per cent water addition depending on the temperature of the sand. Batch size, cooling air, type of muller, muller speed, ambient temperature, and other variables also influence the actual cooling time required.

Second, mulling must be continued after the initial cooling period. This will cause adequate dry strength to be developed and permit the sand to approach the ideal dry and green strength combinations which result from room temperature mulling. The criterion of adequate mulling time for hot sand should be dry compressive strength (or combination of green and dry strength) rather than green strength.

"Gas Pressures in Green Sand Molds," C. T. Marek, Purdue University, West Lafayette, Ind., and C. B. Ward, United States Air Force, Wright-Patterson Air Force Base, Ohio.

Mold pressures decrease with increasing permeability. Permeability being a function of moisture content, changes in permeability up to an optimum of 5.5 per cent moisture tend to counteract the pressure-producing effect of vapor generation. Increasing moisture *beyond* this optimum value however, results in a decreasing permeability with increasing pressure.

Light Metals

"Some Requirements for Successful Fluidity Testing," S. A. Prussin, Pacific Semiconductors, Inc., Culver City, Calif., and G. R. Fitterer, University of Pittsburgh, Pittsburgh, Pa.

Duration of the fluidity test is less than a second, making it impossible for a commercially gated mold to be independent of the human variable. The use of a reservoir fluidimeter design permits fluidity rods to be cast under constant and reproducible metallostatic pressure.

Variation in fluidity length under identical metal and mold conditions was attributed to the dominance of one of two possible mechanisms of flow cessation. There are two regions in the flow-time curve of the fluidity test for a pure metal: an initial constant velocity region probably corresponding to flow while the metal stream is completely liquid, and the final decelerating region during which solidification is occurring.

"New Aluminum-Magnesium-Zinc Casting Alloy," H. C. Rutemiller, Aluminum Co. of America, Cleveland.

A new heat treatable aluminum casting alloy designated as X250 has been developed for applications requiring good ductility, high tensile strength and excellent resistance to corrosion. This alloy contains 8 per cent magnesium, 1.5 per cent zinc, 0.25 per cent manganese, and 0.15 per cent copper.

Casting characteristics and mechanical and physical properties are similar, in general, to those of the aluminum–10 per cent magnesium alloy, 220-T4. But alloy X250-T4 offers two important advantages–better resistance to stress corrosion cracking and greater stability of tensile properties during natural aging.

"Foundry Practice for Sand Casting Commercially Pure Aluminum," R. V. Scalco and M. V. Davis, Anderson Electric Corp., Birmingham, Ala.

The following factors must be considered when sand casting pure aluminum:

1) The solidification range of 25

F (14 C) and solidification shrinkage of 6.6 per cent makes feeding extremely difficult.

2) The tendency of this metal to be "hot short" requires close attention to casting design and core practice, where cores are used.

3) Ease of hydrogen adsorption on the surface of molten metal requires close attention to the melting practice employed.

4) Low mechanical strength necessitates extremely careful shakeout procedures and subsequent handling of the castings to avoid deformation of the castings.

5) Soft aluminum castings cause galling or seizing, as well as loading of saws and abrasives used in cutting gates and risers.

The design of gating and risering systems for sand castings of commercially pure aluminum are designed with these objectives in mind:

1) To provide for feeding castings with a high solidification shrinkage metal.

2) To introduce metal to the mold cavity with a minimum of turbulence.

3) To provide a controlled pouring rate gating system to avoid misruns on the one hand and burnin or washed sand on the other.

4) To introduce metal into the mold cavity at locations conducive to producing temperature gradients that provide for directional solidification.

"A Method of Casting Radiator-Type Fuel Elements for a Nuclear Reactor," A. W. Hare and R. F. Dickerson, Battelle Memorial Institute, Columbus, Ohio.

Optimum casting conditions for the chromium-uranium eutectic alloy were found to be a pouring temperature of 2000 F with graphite mold temperature of 1600 F.

Casting of larger sections of the perforated hexagon appears to be quite feasible, but the core alignment problem probably would increase as the length of the casting increased.

"Induction Melting in a Magnesium Sand Foundry," J. G. House and M. E. Brooks, Dow Chemical Co., Bay City, Mich.

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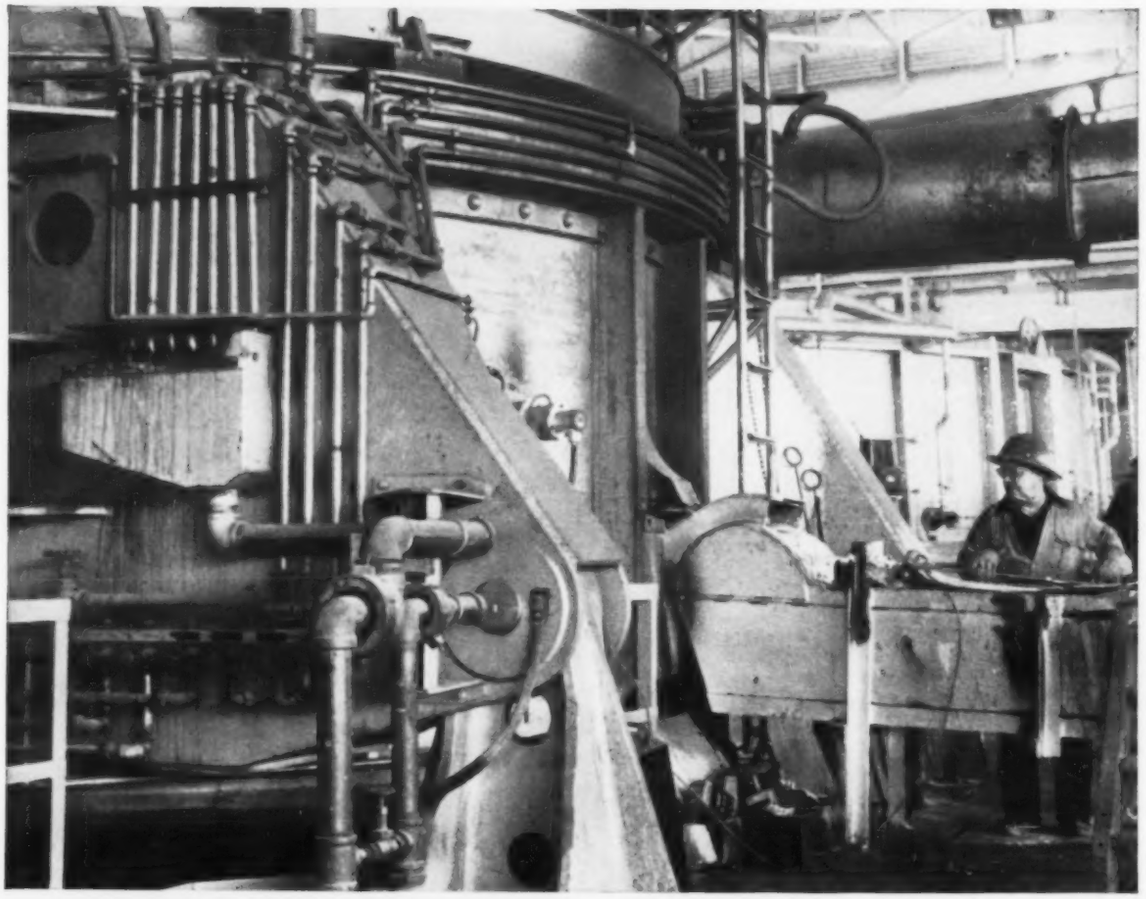

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capable of melting magnesium alloy in the sand foundry under production conditions with production personnel. Based on somewhat limited experience, it would appear that the operating characteristics of the induction furnace compare favorably with those of conventional gas or oil-fired melting units.

The final decision as to whether the induction furnace or the gas or oil-tilter furnace is the more desirable melting equipment will depend upon local considerations, including the relative costs of equipment and installation, fuel and power costs and the molten metal requirements of the foundry.

"Foundry Characteristics of a Rammed Graphite Mold Material for Casting Titanium," H. W. Antes, J. T. Norton and R. E. Edelman, Frankford Arsenal, Philadelphia.

Suitable expendable graphitic molds can be made for casting titanium. Common foundry techniques and equipment may be utilized to fabricate these molds.

Permeability, strength, thermal conductivity, surface finish and shrinkage of these molds can be varied by controlling water content and molding pressure. Satisfactory molds for casting titanium can be prepared from a six per cent water mixture by using minimum molding pressure of 100 psi.

"Improvement of Castings by Press Forging," A. H. Murphy and W. Rostoker, Illinois Institute of Technology, Chicago; and L. L. Clark, Fansteel Metallurgical Corp., Muskogee, Okla.

Substantial increases in the yield and ultimate strengths of castings can be achieved by the application of relatively small deformations applied either cold or warm.

The pressures necessary to develop the requisite deformations are reasonably low particularly when forging is done at about 300-400 F. The choice of elevated temperature must lie below the peak aging temperature if such exists, or at least below the recrystallization temperature. Magnitude of the strength enhancement is independent of the temperature of forging below the peak aging temperature.

There are geometric conditions governing feasible pressures of forging. Using height-to-diameter or height-to-width as measure of this, there are minimum limits below which flow pressures rise prohibitively. A potential process is available by which the cost and isotropy of mechanical property characteristics of castings can be combined with properties approaching those of forgings.

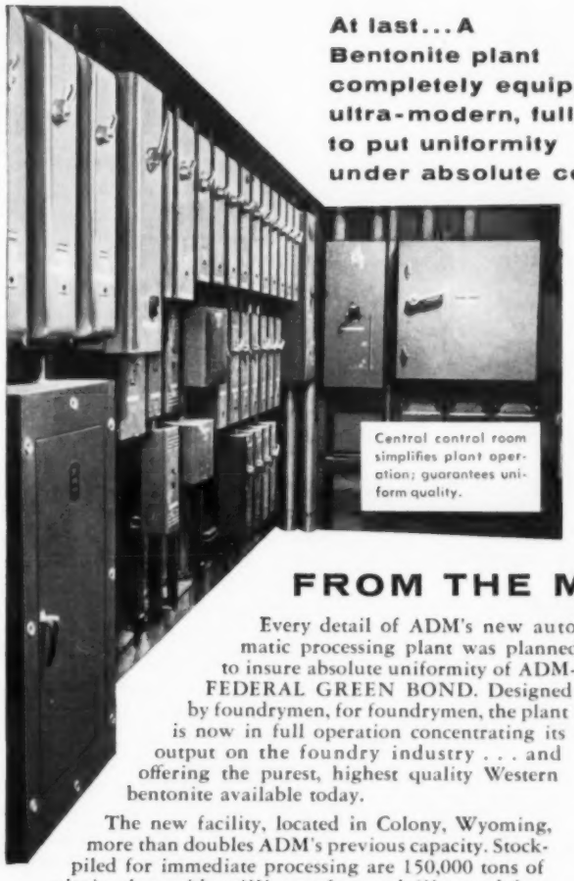
"The Parlanti Mould Process for the Casting of Metal by Controlled Rate of Heat Transfer," Dr. C. A. Parlanti and R. D. Veneklasen, Niforge Engineered Castings, Inc., Boston.

The Parlanti Mould Process comprises a method of controlling the even-cooling of a cast mass in order to obtain optimum physical test figures in castings at least comparable to the test bar figures expected from any particular alloy.

The process makes use of the high-thermal conductivity of aluminum to control both the direction and the rate of heat transfer from the molten metal. The aluminum mold and the face which comes in direct contact with the molten metal is deeply anodized. The anodized layer, essentially Al_2O_3, has a melting point over 3700 F. It is also hard, and, therefore, resistant to erosion and wear, making possible repeated use of the mold.

The anodized film, being a refractory with low thermal conductivity, momentarily checks the flow of heat from the metal as it is poured, keeping it from freezing too rapidly. This film also acts as a barrier enabling the mold to conduct the heat to the inner faces of the mold at a regulated rate without any great heat absorption in its own mass.

As a net result, the first metal to enter the mold is the first to freeze. So controlled pouring produces progressive solidification of the part from the bottom up, the last metal to freeze being the header. Pouring can be rapid, but within the bounds necessary to eliminate turbulence. The solidification process results in a dense casting, while the high cooling rate produces fine grain. Both contribute to improved mechanical properties of parts produced by this system.



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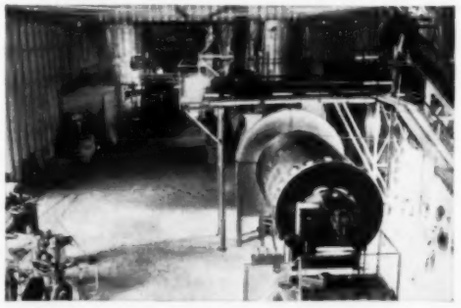
The new facility, located in Colony, Wyoming, more than doubles ADM's previous capacity. Stockpiled for immediate processing are 150,000 tons of virgin clay, with millions of tons drill-tested for purity and ready for mining.

Every chance of human error has been eliminated by the latest production control devices. All measuring and weighing is done by instruments, dryer heat is electronically controlled, material is handled by the most modern pneumatic and belt conveyors, and packaging is completely automatic.

These are a few reasons why ADM-FEDERAL GREEN BOND Bentonite will provide more casting benefits per dollar than any binder of its kind.

The Colony operation is further evidence of ADM's determination to provide the foundry industry with intelligent solutions to their casting problems. Talk to an ADM field service representative today and you'll see these attitudes reflected. Why not visit our new plant soon?



Interior of processing plant illustrates in-line arrangement of equipment. Dryer is shown in foreground.

The new bag design for ADM-FEDERAL GREEN BOND Bentonite is now labeled with the familiar Archer trademark, your guarantee of quality.*

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Circle No. 261, Page 7-8

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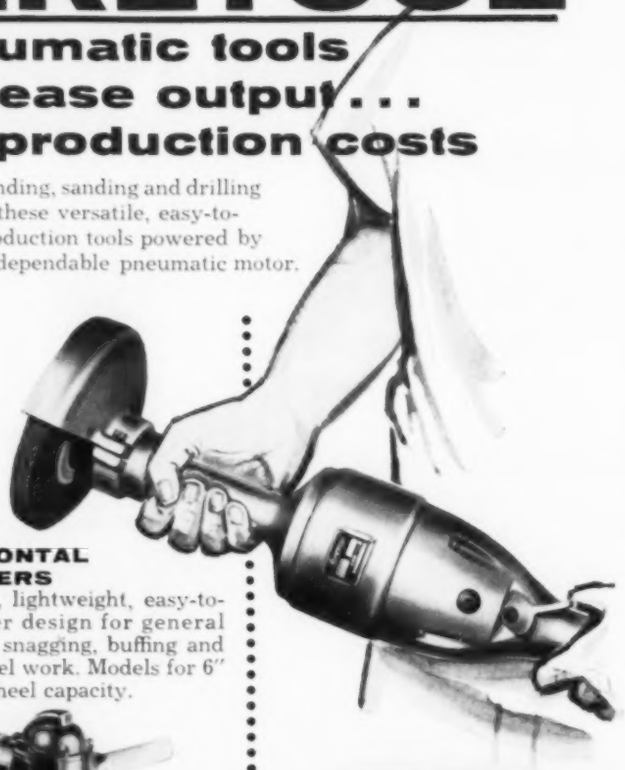

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Circle No. 262, Page 7-8

"Tensile Properties of Microshrinkage – Graded AZ63 Magnesium Alloy," J. D. Grimsley and I. J. Feinberg, U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md.

Microshrinkage in magnesium alloy AZ-63 is detrimental to all of the tensile properties commonly used in acceptance criteria. It damages elongation severely, tensile strength moderately and the yield strength slightly. Transverse alignment reduces elongation and ultimate strength more than the longitudinal alignment. Longitudinal alignment was found to be slightly more severe on yield strength. Therefore it is apparent that microshrinkage in castings should be evaluated with respect to its orientation relative to service stresses.

Reliable estimates of mean properties can be obtained through statistical analyses. Thus, fitted straight lines were found to be adequate in representing decreases in ultimate strength, elongation and transverse yield strength with increase in microshrinkage degree. The 95 per cent confidence limits, within which the true means were found, vary with the scatter arising from true radiographic assignment and inherent casting material variations.

There is now considerable arbitrariness involved in radiographic specifications limiting the degree of microshrinkage allowable for particular applications. In overcoming this the application of an adequate strength level for highly stressed areas requires one approach; the economic utilization of inferior grades of material where property requirements are not stringent requires another.

"Effect of Impurities upon the Resistance of Magnesium Casting Alloys AM262 and AM266 to Corrosion," B. J. Nelson, Aluminum Co. of America, New Kensington, Pa.

The tensile strengths of the AM-262 and AM266 alloys, where compared to AM260 and AM265, are decreased slightly but the yield strength is increased somewhat by the additional amounts of copper and of silicon which are present in the AM262 and AM266 alloys; nickel has little if any effect on the properties.

Some natural aging occurs in sand cast AM262 and AM266 alloys; the evidence is less convincing for permanent mold cast AM-262. In addition, the properties of the alloys in the -T6 temper are decreased slightly by natural aging. In NaCl environments, alloys having the same range of impurity content, including nickel, have similar resistance to corrosion.

In general, acid-dipped bars are more resistant to corrosion than are chrome-pickled bars where the corrosive element is greater than moderate. This is probably due to the local breakdown of the chrome-pickle, which leads to a pitting attack rather than an over-all general surface corrosion.

Based upon exposures of up to seven years in a marine atmosphere, all alloys of low nickel content have about the same resistance to corrosion; higher nickel contents lead to an inferior resistance to corrosion.

In an industrial atmosphere, the corrosion resistance of different groups of alloys of the same temper appear similar. There is little if any difference in this test between the over-all atmospheric corrosion resistance of alloy bars which are acid-dipped or chrome-pickled. In this case, any breakdown of the chrome-pickled surface is slow, and a pitting type of attack does not seem to occur.

"A Casting Technology for Reactive Metals," F. W. Wood, S. L. Ausmus and E. D. Calvert, U. S. Bureau of Mines, Albany, Ore.

Consumable-electrode, cold mold arc-casting in a vacuum has been demonstrated to be a practical method of processing reactive metals. The technique is adaptable to the production of special shapes by either static or centrifugal casting and in some instances provides the only means of satisfying requirements for corrosion resistance, alloy homogeneity, high temperature strength or special nuclear properties.

The practice should not be considered competitive with vacuum induction casting, levitation melting or electron gun melting. Instead, these methods supplement each other yielding a broad range of processes capable of satisfying a broad range of requirements.

"High Strength Aluminum Alloy X357, Properties and Aging Practices," A. B. DeRoss, Kaiser Aluminum & Chemical Sales, Inc., Chicago.

It is important with high purity alloy X357 that foundry melting practices be controlled to eliminate the possibility of iron pick up or other impurities from equipment or from foreign contaminates. The chemical composition of the alloy should be maintained as close to the nominal amount as possible. This is particularly true of the magnesium content 0.50 per cent nominal. A significant reduction in tensile and yield properties apparently can result if the magnesium content is allowed to drop below 0.45 per cent.

Fluxing with chlorine gas is desirable although it must be well controlled as excessive chlorine gas fluxing will remove magnesium and thereby reduce the net amount of magnesium remaining in the casting. Although chlorine gas is an excellent fluxing agent, its use in high purity X357 is not altogether necessary.

Aluminum chloride, hexachloroethane and other generally accepted chemicals are suitable. High purity alloy X357 has excellent mold filling characteristics, machinability, dimensional stability and corrosion resistance.

"Rigging Design of High Strength Magnesium Alloy Castings," M. C. Flemings, R. W. Strachan, E. J. Poirier and H. F. Taylor, Massachusetts Institute of Technology, Cambridge, Mass.

By judicious chilling of heavier section castings and by careful foundry practice, the mechanical properties of magnesium alloy castings may be raised substantially above present design minimums.

In a heavy section AZ91C alloy casting (1/2-in. to 2-in. section size) the techniques described, including chilling, resulted in an average improvement of 70 per cent in ultimate tensile, 34 per cent in yield strength and 400 per cent in elongation over present required design minimums. In a similar AZ92A alloy casting, the techniques resulted in 60 per cent increase in ultimate tensile strength and 30 per cent increase in yield strength.

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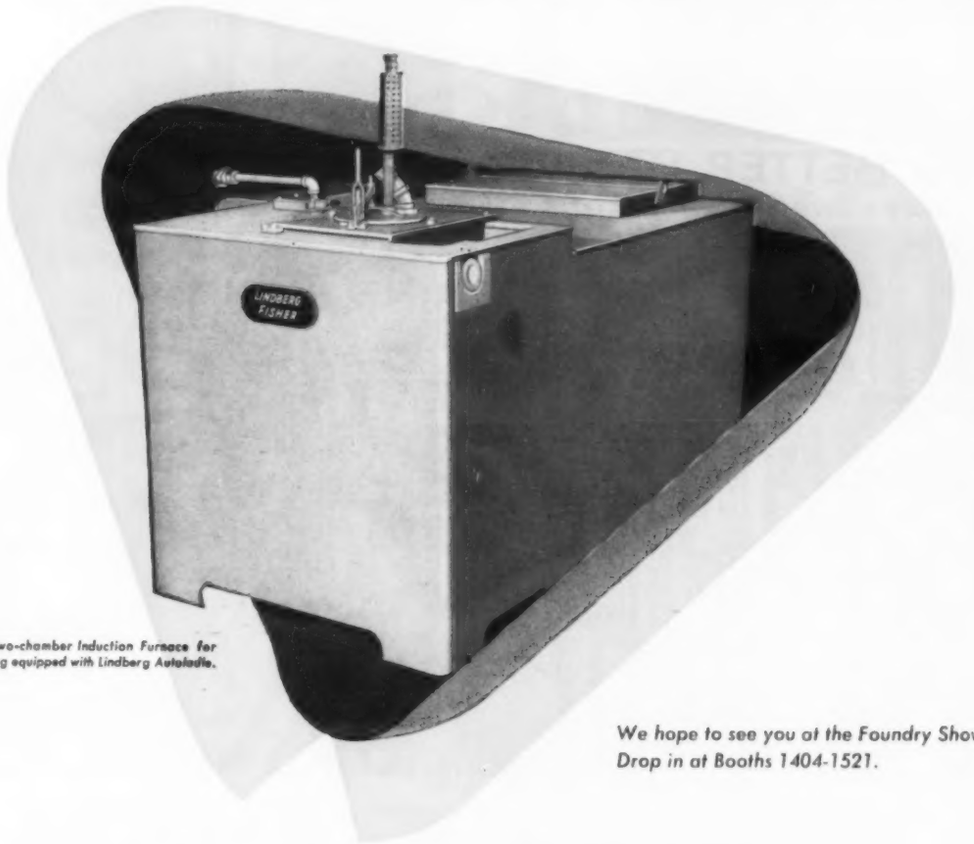

Lindberg-Fisher two-chamber Induction Furnace for melting and holding equipped with Lindberg Autoladle.

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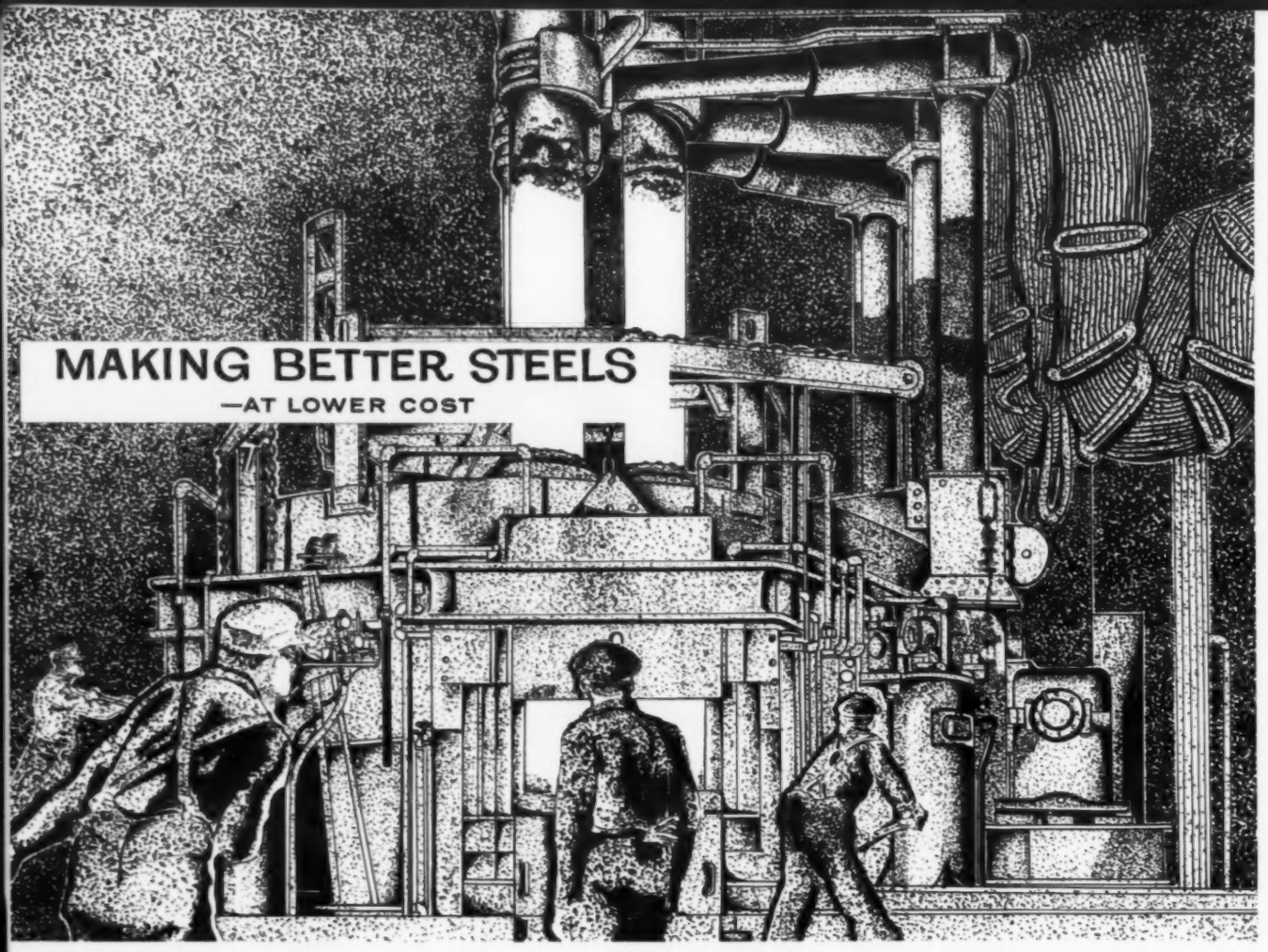
LINDBERG heat for industry

Circle No. 263, Page 7-8



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In the light section casting investigated (1/10-in. to 1/2-in. section size) chills were found to be unnecessary for obtaining optimum properties. Unchilled castings of both AZ91C and AZ92A alloys made with careful foundry practices were found to possess ultimate tensile strengths about 40 per cent above present values.

"The Release of Hydrogen from Molten Aluminum," A. Pal, Annapurna Metal Works, Calcutta, India, and H. M. Davis, Pennsylvania State University, University Park, Pa.

A significant portion of the hydrogen in molten aluminum can be removed by treatment with briquettes containing magnesium oxychloride weighted with corundum. The decomposition products of the briquettes make no objectionable addition to the aluminum.

In the experiments reported, the porosity of the briquette-treated metal was largely attributable to shrinkage. The corollary is that higher densities could have been attained in the briquette-treated ingots had the feeding been adequate. Unless continued solidification toward the feeding head is realized (mainly through design of the mold), the beneficial effect of the flushing is masked by unsoundness.

"An Improved Design for Cast Tensile Bar Molds," M. Karnowsky, Sandia Corp., Albuquerque, New Mexico.

Observation of a lucite model of the QQ-M-151 test bar mold design showed the following:

1) Air bubbles clean up slowly in the well.

2) Turbulence is induced by the chokes or dams.

3) The design of the runners induces turbulence at two points.

4) Fluid flow is unequal in the three cavities.

Since the turbulence in the runners and the irregularity with which air escapes from the mold could account for variations in the dross characteristics of the tensile bars produced from such a design, an attempt to construct an improved mold was made. Runner

Circle No. 264, Page 7-8

design has been studied by a number of investigators. The following principles were used in this attempt:

1) Large radii should be used for direction changes.

2) Runners should be in the drag and ingates in the cope when possible.

3) The total cross-sectional area of the runners in a two-runner system should equal 6 times the bottom area of the sprue. (In a single runner system, the runner area should equal four times the area of the sprue.)

"Problems Encountered in Casting Reactive Metals," W. A. Aschoff and D. H. Blair, Oregon Metallurgical Corp., Albany, Ore.

Before shape castings can be expected to occupy the quantitative position they deserve in the reactive metals field, we must solve the questions of gas porosity and temperature control. The problem of what to do with conventional alloys, heat treatment and developing better alloys specifically for casting must be solved. The problem of better and more efficient methods of making these castings to reduce cost and of selling the prospective customers on the advantages and availability of these shapes must be answered.

"Performance of Chills on High Strength Magnesium Alloy Sand Castings of Various Section Thickness," M. C. Flemings, R. W. Strachan, E. J. Poirier and H. F. Taylor, Massachusetts Institute of Technology, Cambridge, Mass.

Chilling substantially improves the properties of a heavy section casting in both AZ91C alloy and AZ92A alloy. Properties of an unchilled heavy-section casting of AZ91C alloy averaged 24,200 psi ultimate tensile strength, 16,500 psi yield strength and one per cent elongation.

Chilling raised these average properties to 43,500 psi ultimate tensile strength, 23,800 psi yield strength and three per cent elongation.

"The Effect of Cooling Rate on the Grain Size of Magnesium Casting Alloys," R. D. Green, Dow Chemical Co., Midland, Mich.

A study of the effect of cooling rate on the grain size of several magnesium - aluminum - zinc alloys and a magnesium-rare earth zinc alloy shows that the grain size of Mg-Al-Zn alloys is established at 50 F below the liquidus. For the case of the Mg-Re-Zn alloy, the grain size is established at 30 F below the liquidus.

Correlation of grain size and cooling rate through the above ranges shows that in Mg-Al-Zn alloys the grain size decreases as the cooling rate increases to 200 F per min and then remains constant with increases to 600 F per min.

There is little effect of cooling rate on the Mg-Re-Zn alloy grain size. The effect of cooling rate on grain size is explained on the basis of constitutional supercooling and nuclei effectiveness.

Management

Getting the Most Out of Yourself, R. Monsalvatge, Dayton, Ohio.

Monsalvatge outlined traits that make up the successful employee: sincerity, integrity, humility, courtesy, wisdom, charity—criteria, (according to the famed psychiatrist, Menninger) essential to maturity. Your employer is looking at you as a leader, teacher and student—a person of action.

He emphasized the importance of picking out a definite goal, analyzing the necessities in reaching it, planning actions and following them. We must realize that the biggest price one has to pay for self-development is effort. Too many consider this too great a price to pay.

Creating A Climate For Management Development, R. B. Parker, American Brake Shoe Co., New York.

Parker believes the most important single problem now facing foundry management is that of finding and developing top executive material. A common mistake is thinking that because a man is a salesman, an accountant, or in some other position, he is capable of nothing else. You'll never know what a man's capabilities are until you give him a chance to prove himself. Management must create a climate that will give the employee a real opportunity to extend himself, to reach out beyond the borders of his present job.

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The chances are 3 to 1 that your blast cleaning operation costs you far more than it should. Check this list and see how many ways you can save.

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1. Throwing the maximum amount of abrasive at the work?			
2. Throwing an abrasive mixture with a full range of sizes, and no contaminants?			
3. Throwing all the abrasive upon the work with minimum wear on machine parts?			
4. Using the abrasive best suited for your application?			
ARE YOU GETTING MAXIMUM CLEANING ECONOMY BY ELIMINATING ABRASIVE LOSSES:			
1. Through the separator system?			
2. Through the dust collector and ventilation system?			
3. Through abrasive carried out with the work?			
4. Through cabinet leaks and poor housekeeping?			
ARE YOU REDUCING MAINTENANCE COSTS AND PRODUCTION LOSSES BY:			
1. Obtaining longest possible life from wear parts?			
2. Using preventive maintenance to reduce "down time"?			

If you have to answer "no" or "don't know" to any of these questions, you're gambling with potential profit dollars. The best way to eliminate this gamble and save any profit "waste" is described in Wheelabrator Abrasive Bulletin No. 902D. Write for your copy today.

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Circle No. 265, Page 7-8

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AND NEW, HIGHLY EFFICIENT
DEGASERS

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Photo shows pinhole porosity which resulted with untreated aluminum alloy casting.

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This photo shows how pinhole porosity is eliminated completely when casting is treated with Foseco COVERALS and DEGASERS.

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Efficient Foseco Coverals and *new* Foseco Degasers, more efficient than ever, are available for use in all types of melting furnaces, and for treating *all* aluminum alloys.
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Circle No. 266, Page 7-8

the SHAPE of things

safety, hygiene, air pollution

BY HERBERT J. WEBER

Is Noise A Racket?

Some people think noise is a racket not only in the acoustical sense of the word but also in the slang meaning of it.

The reason for this view is that some states have made occupational loss of hearing compensable even though the original intent of the Workmen's Compensation Act was to compensate an industrially injured worker for loss of earning capacity resulting from his injury.

Now in the case of industrial deafness there is seldom any loss of earning capacity because the very noise which created the hearing impairment is usually so intense that communication by means other than speech is necessary. Thus the worker can continue in his job earning full wages.

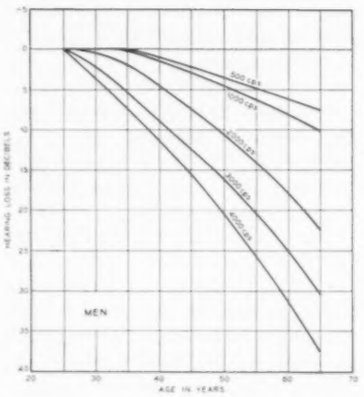
However, certain states, notably New York and Wisconsin, have made occupational loss of hearing compensable under the Workmen's Compensation Act. Other states are about to follow the precedent which can only result in increased insurance costs.

What can foundrymen do about this right now? Sometimes the engineering control of noise is difficult and expensive and even if the foundry noise were controlled tomorrow what about employees previously exposed to noise? Do they now sustain a hearing impairment because of previous exposure, and if so, how much?

What about new job applicants? Did you know that 25% of all applicants already have hearing loss? And that some have losses as high as 50 decibels in each ear? Some day you will pay for this hearing loss because you did not know it previously existed . . . UNLESS . . .

You begin a program of pre-employment and periodical audiometric testing. The audiogram will tell you how much hearing loss a job applicant had before you hired him and it will tell you also the hearing condition of employees already on your payroll. Even when you transfer an employee from one department to another an audiogram should be taken.

The audiogram will help you locate the noise susceptible individual who should not be subjected to a noisy environment. The audiogram also guides you in proper job placement; protects you against paying for loss of hearing for which you are not responsible; and enables you to hire people having hearing loss without prejudice.



Normal hearing losses as men age.

In fact, I know of a forge shop that hired a deaf mute. While the hearing of speech is impossible in the shop, you never call this man any names if he is looking at you, not only because he's a giant, but because he can read lips.

It doesn't cost much to have an audiometric testing program, but if you think your operation is too small, have you ever thought of running a co-op for audiometric testing with other foundries or other plants in your area?

If you need further convincing of the value of audiometric tests look at the figure which shows that normal hearing losses begin shortly after men reach age 25.

The frequencies important for speech intelligibility are contained between 500 and 2000 cps. The expression, "Presbycusis losses", means hearing loss due to increasing age. The curve is related to the general male population and indicates that hearing losses exist regardless of occupation.

foundry trade news

NFFS 1958 Government Industry luncheon guests were: R. C. Meloy, Marketing Director Gray Iron Foundry Society; M. E. Nevins, Wisconsin Centrifugal Foundry Co., Waukesha, Wis.; Wm. H. Franklin, Chief, Operations Branch, Copper Div., BDS, Washington, D. C.; C. J. Egetter, Crown Brass Mfg. Co., Alhambra, Calif.; and in the back row P. E. Lankford, East Birmingham Bronze Foundry Co., Birmingham, Ala.; A. A. Snow, Aluminum & Magnesium Div., BDSA, Washington, D. C.; Elmer Brummund, Brummund Foundry Co., Chicago and Herb Scobie, NFFS executive secretary.

NON-FERROUS FOUNDERS' SOCIETY, . . . Evanston, Ill., held the 15th anniversary program in the Carter Hotel, Cleveland. Combining management sessions, board and executive sessions, board and committee meetings and a breakfast for NFFS management group officers, this year's meeting also included a meeting and luncheon of the newly-formed Cast Bronze Bearing Institute, a Society affiliate. Presiding was C. J. Egetter, president, Crown Brass Mfg. Co., Alhambra, Calif., and president of NFFS during the past year.

National officers elected were President – P. E. Lankford, partner, East Birmingham Bronze Foundry Co., Birmingham, Ala.; 1st vice-president – M. E. Nevins, president, Wisconsin Centrifugal Foundry Co., Waukesha, Wis.; 2d vice-president – E. G. Brummund, Jr., vice-president, Brummund Foundry, Chicago. Herbert Scobie, executive secretary, continues as secretary-treasurer. Florence M. Guernier, Highland Park, Ill., was named assistant secretary-treasurer.

At the AFS Show held in Cleveland NFFS exhibited castings produced by member firms and recorded requests from castings users for the 1958 NFFS Castings Buyers' Guide soon to be issued.

Highlight of the annual meeting was NFFS Government-Industry Luncheon. President-elect P. E. Lankford presided. *The Industry and the Copper Division* was discussed by W. H. Franklin, Copper Div., Business & Defense Services Administration, Washington, D. C.; A. A. Snow, director, Aluminum & Magnesium Div., B.D.S.A., spoke on *Mobilization and the National Executive Reserve Program*. Other speakers and their subjects were: *Supervisory Incentives*, J. W. Horner, Jr., Slack-Horner Brass Mfg. Co., Longmont, Colo.; *How to Get Your Share of the Market*, R. C. Meloy, marketing director, Gray Iron Founders' Society, Cleveland; and *Impact of Pension Trust Costs*, Ted Snyder, Russell M. Trolley & Associates, Indianapolis. A dramatization of selling techniques prepared by H. A. White, Smeeth-Harwood Div., Capital Brass & Aluminum Foundry Co., Chicago, featured W. M. Clark, D. W. Clark & Co., Inc., East Bridgewater, Mass., as purchasing agent, and G. T. Fischer, Fischer Casting Co., Dunellen, N. J., and J. F. Gilbert, Gilbert Brass Foundry Co., St. Louis, as salesmen.

THE FOUNDATION FOR MANAGEMENT RESEARCH . . . Chicago, reported that despite current dip in capital spending, leasing of capital equipment in first four months of 1958 showed a 14 per cent gain over the similar period a year ago – according to information gleaned from United States Leasing Corp. Largest users of leased industrial equipment today are 10 manufacturing industries; pulp, paper and allied products; electrical equipment and machinery; chemicals and drugs; rubber products; fabricated metal products; petroleum refining; food products; lumber and wood products; aircraft and parts; and printing-publishing. While major industrial items leased (aside from automobile fleets) are machine tool and metal forming group (lathes, milling, boring machines, hydraulic presses and forges), there has been a decided spurt in leasing of mining equipment, construction machinery, pumps, diesel power, cranes, electrical apparatus, communications systems and printing presses.

For companies interested in examining advantages and disadvantages of leasing industrial equipment, or even entire plants, a recent study is available entitled "Leasing and American Industry". For a copy circle C, Reader Service Card, page 7-8.

U.S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES, . . . Fort Belvoir, Va., held a conference on steel castings. Importance of industrial development of lightweight, high-strength materials to new mobile military equipment was stressed. The three-day conference, sponsored by the Laboratories in cooperation with other government agencies, was presented jointly with Steel Founders' Society of America, Alloy Casting Institute and Investment Casting Institute. A. L. Tarr of the Laboratories and A. J. McDonald of S.F.S.A. served as chairmen.

The program covered the use, design, specifications and inspection of steel castings, and featured lectures by leading experts. Approximately 175 representatives of government and industry attended. Subjects covered were: the use and purchasing of steel castings; elements for design of steel; inspection of steel castings; the importance of high-alloy castings in the design of structural equipment; and selection of alloys for various types of corrosive service, covering the heat-resistant cast alloy grades.

Dramatic possibilities of the investment casting process in producing close to size components indicated several potential types of applications for Army Corps of Engineers consideration. Variations from regular casting procedures from the viewpoint of specifications, use, design and inspection were covered.

Steel castings conference attended by government and industry representatives. Shown here with Col. A. H. Davidson, Jr. (center), Lab's director, are (left to right) F. K. Donaldson, executive vice-president, A. J. McDonald, Washington representative, and R. L. Gilmore, president Steel Founders' Society of America, and A. L. Tarr, USAERDL, conference general chairman.

THE FOUNDRYMEN'S CLUB . . . banquet, July 29, to be held at General Motors Institute, Flint, Mich., will feature E. N. Cole, general manager, Chevrolet Motor Div., and vice-president, GMC as the main speaker. The Foundrymen's Club, organized in 1954, is promoting the third annual senior's banquet, and is preparing a car and casting display to be held in the gymnasium of GM Institute. Cars of the five GMC car divisions and the castings used in these cars will be shown.

MALLEABLE FOUNDERS' SOCIETY . . . Cleveland, have elected to the Board of Directors, for a four year term which began June 1, 1958, Joseph Abusamra, (president, Belcher Malleable Iron Co., Easton, Mass.); R. S. Bradshaw, Jr., (president, Texas Foundries Inc., Lufkin, Texas); and T. T. Lloyd, (vice-president, Albion Malleable Iron Co., Albion, Mich.)

American Malleable Castings Co. . . . Marion, Ohio, installed pearlitic malleable iron production facilities. This addition, another phase of their com-

plete plant and equipment modernization program, makes it possible to produce both standard and pearlitic malleable iron castings in the Marion plant.

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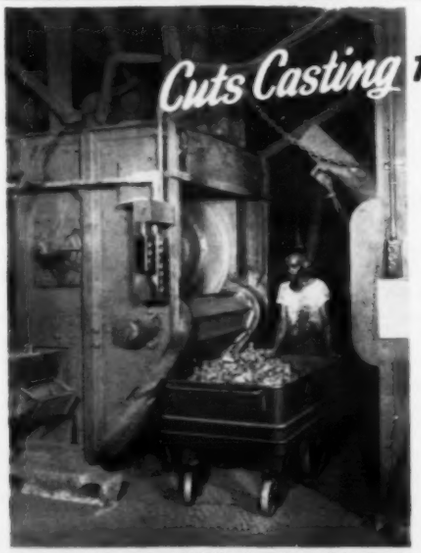

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Founded 1904 as
Sterling Wheelbarrow Co.
Milwaukee 14, Wisconsin, U.S.A.

Illustration shows one of 25 Sterling Heavy Duty Trucks in daily use at the Green Foundry, St. Louis, Mo.

Sterling
FOUNDRY EQUIPMENT

Circle No. 267, Page 7-8

Build an idea file for plant improvements. Reader Service Cards, page 7-8 will bring more information . . .

for the asking

Foundry methods . . . sheets describe methods of determining resin particle size, heated inclined plate flow, film cure and core binder viscosity, solids content and specific gravity. Also specification sheets for liquid core binders and synthetic resins. *Reichhold Chemicals, Inc.*
Circle No. 341, Page 7-8

Scrap control . . . facilitated by sand-cleaning unit illustrated in brochure. Features pointed out in photos and line drawings. Unit designed for use with front-end loader. Large scrap discharged at wheelbarrow height; ferrous scrap which passes through grid mechanism separated from sand by magnetic pulley. *Royer Foundry & Machine Co.*
Circle No. 342, Page 7-8

Epoxy resins . . . applications and advantages presented in 8-p brochure. Well-illustrated booklet summarizes uses of epoxy compounds in various industries including metal-forming, plastics, foundry, chemicals and electronics industries. Contains applications and advantages of plastic tooling, potting, impregnating, coating and adhesive resins. *Marblette Corp.*
Circle No. 343, Page 7-8

Shell molding . . . with forsterite grains described in 4-p brochure. Covers history and description of shell-molding process as well as properties and development of forsterite. Preparation and use of forsterite shells outlined. Also includes a glossary of terms used. *Harbison-Walker Refractories Co.*
Circle No. 344, Page 7-8

Die-casting alloys . . . their properties and industrial applications, are described in 32-p booklet. Lists die-casting alloy specifications of the A.S.T.M., S.A.E., U. S. Army, U. S. Navy and Aeronautical Material Specifications. Also contains discussion of modern die-casting practice, including gating and venting of the dies, metal injection pressures, surface finish of the dies, temperature and important factors to be considered when designing castings. *American Smelting and Refining Co.*
Circle No. 345, Page 7-8

Time-zone map . . . depicting standard time zones of the United States and Canada offered. Suitable for wall or desk-top locations, the map

is printed in three colors on 8-1 2 x 11-in. card stock. Useful for those who are frequent long-distance phone callers. *Ohio Seamless Tube Div. Copperweld Steel Co.*
Circle No. 346, Page 7-8

Foundry coke . . . performance evaluated in experimental cupola. Test procedures and results summarized in brochure which includes line drawing of cupola. Data obtained said to improve quality of foundry coke. *Hickman, Williams & Co.*
Circle No. 347, Page 7-8

Cobalt reference lists . . . available referring to literature published on cobalt in aluminum alloys, patents, and cobalt in heat-resistant and high-creep-strength austenitic steels and alloys. Refers to publications from 1908 to 1957. *Cobalt Information Center, Battelle Memorial Institute.*
Circle No. 348, Page 7-8

Nuclear engineering technology . . . home-study course offered by Washington, D. C. technical school. Ob-

Continued on page 119

FOUNDRY FACTS NOTEBOOK

FIRST AID FOR ASPHYXIA

FOUNDRY FACTS NOTEBOOK *is designed to bring you practical down-to-earth information about a variety of basic foundry operations. As the name implies, this page is prepared for easy removal and insertion into a notebook for handy future reference.—Editor*

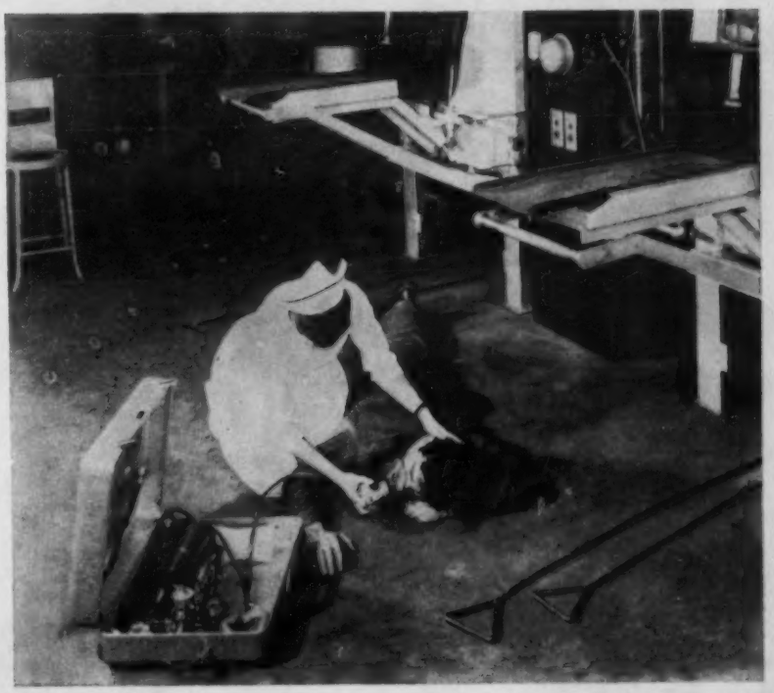
by J. B. DUNNE
Medical & Hospital Dept.
Globe Industries, Inc.
Dayton, Ohio

Every industrial and commercial plant faces the constant threat of death to its employees by asphyxia. Although this has been the situation for decades, this threat is now becoming greater because of the increased use of more dangerous chemicals and raw materials; electrically-operated equipment is being used for more production work; and extended use of combustion equipment has added to the ever present threat of carbon monoxide poisoning.

The setting up of an efficient and workable over-all program for in-plant treatment of asphyxia, pulmonary or cardiac cases involves the coordination of accident prevention training with the use of efficient modern respiratory assistance equipment. Although the industrial physician and the nurse in the dispensary will be the focal point for the treatment of these cases, this type of program should be integrated with the over-all functions of the safety engineer and industrial hygienist, so that prevention and treatment go hand in hand.

Preventive Measures . . . will require the full cooperation of management and supervision. Organized labor will also find that it has a definite stake in the program. All potentially hazardous materials, practices and equipment should be carefully analyzed and any dangers listed. A helpful guide is contained in the Table. It points out the more common types of hazards and should be of help in laying out the investigative phases.

A vital phase of the preventive program is the correct training of select personnel in each department in first aid, and particularly in the standard technique of manual artificial respiration. Since the first few seconds in cases of asphyxia can mean the difference between life and death, the need for immediate application of manual respiration is apparent. In this way the patient can be adequately ventilated until the portable resuscitator can be brought into use.



Resuscitator has been brought into quick action here to assist the breathing of an asphyxia victim in a heat treat department.

Treatment of Cases

Manual artificial respiration is fairly reliable, but its effectiveness may be affected by fatiguing of the operator, the lack of an oxygen-enriched air supply and the possibility of harm to an injured patient if it is not properly and uniformly applied.

The automatic resuscitator eliminates these disadvantages because it provides a concentrated and controlled supply of oxygen; it can be used on injured and burned patients in inaccesible places; it

Blood Stream Absorption is the Key to Asphyxia

Gases drawn into the lungs during respiration, unless they are of the simple asphyxiant or irritant type, do not exert any physiological action until they have been absorbed into the blood stream through the alveolar tissue. The nature and severity of the reaction which follows is dependent upon the concentration of the poisonous substance in the blood, the length of time which it remains in the blood and the comparative toxicity of the material.

The four factors which determine the effect of an inhaled poisonous gas or vapor upon the body are concentration, duration, toxicity and individual susceptibility.

Changed Within Body

Two classes of gases exert an effect on the body after absorption into the blood stream, the reactive and the non-reactive. A reactive substance is one which is changed within the body and is eliminated in forms other than that in which it was absorbed.

The poisonous action can be exerted either by the original substance or by the product of its decomposition. An example is ethyl alcohol, which exerts its action before decomposition has taken place, but which is eliminated from the body in other forms. Aniline is another example of a vapor which exerts its main action through the products of decomposition rather than as the original substance.

Not Changed

A non-reactive substance is one which is not changed to any great extent within the body and is, therefore, eliminated in the same form in which it was absorbed. Simple or uncombined aliphatic hydrocarbons (so-called "straight chain" series) such as methane, ethylene and acetylene are examples of non-reactive gases and vapors.

Certain of the irritating gases require considerable time for developing their entire effect on the lungs so that at first there is little or no irritation. Some hours later, after a period of but minor discomfort, if any, serious symptoms or death may occur. Nitrous fumes and phosgene are gases of this type.

With methyl chloride, methyl bromide, and ortho tricresyl phosphate (reactive compounds), a longer latent period (sometimes several days) may follow exposure. This is because of the time necessary for these substances to change within the body to other compounds. In other cases, as with

FIRST AID FOR ASPHYXIA

Potential Hazards

Class	Type	Preventive Measures
1. Diseases	a. Cardiac conditions b. Asthmatic and circulatory cases c. Hypertention sufferers	Regular physical checkups; Constant surveillance and encouragement to observe the doctor's suggested regimen; Employee instruction and job selection.
2. Equipment	a. Chemical, oil tanks b. Vats and containers c. Poorly ventilated rooms	Hoods over tanks, etc. Exhaust systems Make-up air systems Oxygen masks (self-contained breathing apparatus) where required for special areas and jobs. Employee training.
3. Electricity	a. Power and transmission lines b. Powered equipment c. Transformers d. Portable power tools e. Lightning	Signs, painting and guard rails and fences. Continuous maintenance and visual inspection of tools. Proper grounding of tools. Isolation of areas. Employee training.
4. Asphyxiating gases	a. Carbon monoxide b. Exothermic and endothermic atmospheres c. Carbon dioxide d. Volatile hydrocarbons	Signs, painting guard rails and fences. Hoods and exhaust equipment. Continuous atmosphere sampling and checking with detecting equipment. Regular maintenance of all equipment, pipes, fittings and tanks. Oxygen masks (self-contained breathing apparatus) where required for special jobs and areas not rendered safe by the other methods. Employee training.
5. Chemical irritants	a. Chlorine b. Ammonia c. Hydrochloric acid d. Hydrogen sulphide e. Lime f. Sulphur g. Hydrofluoric acid gas h. Nitrous fumes i. Bromine j. Beryllium k. Chloride of lime l. Nitric acid m. Phenols n. Phosgene o. Anticholinesterase agents p. Benzol q. Naphthol r. Sulphuric acid s. Hydrocyanic acid	

can be used indefinitely; it signals automatically when the throat is obstructed and respiration is not taking place.

Some medical authorities advocate the use of positive pressure on inhalation and negative pressure on exhalation when using the resuscitator. Others believe in using intermittent positive pressure on inhalation, allowing exhalation to take place by passive recoil. The most modern resuscitators permit a choice of either method.

These modern resuscitators are also designed for the maximum safety of the patient. Pressure relief valves are provided on the high pressure regulator, and pop-off valves are included on the facepiece to vent any excess positive or negative pressure. They also have an inhalator arrangement which permits administration of oxygen without pressure to the breathing patient. An aspirator for sucking out mucous and liquids is also part of the resuscitator kit, along with a means of diluting the oxygen.

The same key people who are trained in the use of manual artificial respiration should also be taught the basic steps in the operation of the portable resuscitator.

Step 1—Bring portable unit to the scene of the accident as soon as possible. Open case and remove resuscitator valve, hose and aspirator.

Step 2—Position patient properly and connect proper face piece to resuscitator valve and turn it on. Automatic artificial respiration will start as soon as the mask is placed against the face of the victim. (It usually takes 10 seconds to complete these steps.)

Step 3—If the resuscitator valve "clicks" rapidly, mask is removed and aspirator is inserted to remove throat obstruction.

Step 4—When patient's breathing becomes spontaneous, the turn of a knob converts the unit into an inhalator, and oxygen flows to him without pressure.

Resuscitation . . . is used when breathing has stopped, as is often the case with electric shock, drowning, smoke inhalation, gas poisoning, concussion and many others.

Inhalation . . . requires only a simple valve adjustment to provide a steady flow of oxygen at 36 liters per minute to the patient who is breathing feebly or laboriously. On each breath he will inspire extra oxygen to enrich the blood supply.

Aspiration . . . is required when the air passages are obstructed by fluids or mucous. This condition is detected by a rapid clicking of the valve. By quickly switching to the aspirator, the obstruction is readily removed. Victims of drowning or chemical inhalation will often have fluid in their throats.

Demand Inhalation . . . provides oxygen to the patient who is breathing normally or near normally, *only* when he spontaneously inhales. This method for supplying additional oxygen is ideal for smoke inhalation cases and for heart attack and asthma patients.

amido and nitro compounds of benzol and its homologues, the combination of another poison, such as alcohol, which may be drunk, produces serious symptoms.

Non-Reactive Absorption

The absorption of non-reactive vapors and gases depends upon the solubility of the substance in the body fluids, the rate of solution (absorption), the rate of lung ventilation (frequency and depth of respiration), and the rate of circulation of the blood. Changes in any one of these factors affect the ultimate action of a substance on the body.

Non-reactive gases and vapors are eliminated chiefly through the lungs. The urine and other excretions carry away relatively small amounts. The concentration of the gas dissolved in the urine corresponds to that in the blood passing through the kidneys at the moment the urine is secreted. The elimination through the lungs follows definite principles similar to those of absorption.

Reactive Absorption

In general, the process concerned in the absorption of reactive gases is the same as for non-reactive gases. There is a difference in that the reaction and consequent destruction of the gas prevent the attainment of equilibrium which usually occurs from breathing non-reactive gases. The elimination of reactive substances is influenced by their alteration within the body, the amount of substance eliminated being less than the amount absorbed.

The classification of gases and vapors suggested by Henderson and Haggard in *"Noxious Gases and the Principles of Respiration Influencing Their Action."*

1) *Asphyxiants*—do not directly injure the respiratory tract, but produce effects by causing a condition of oxygen deficiency in body tissues.

2) *Irritants*—injure certain tissues of the respiratory tract causing inflammation of the respiratory passages and in some cases the lungs.

3) *Volatile drugs and drug-like substances*—the anesthetic group, these substances have a drug-like action after absorption through the lungs.

4) *Inorganic and organometallic substances*—some are true poisons. Action observed after absorption into blood stream.

This group has a wide diversity of action. Some are essentially tissue poisons. The action of these compounds is observed only after absorption into the blood stream.

■ Reprinted from National Safety Council phamphlet No. 9, *"Gases and Vapors."*

for the asking

Continued from page 116

jective of course, available this fall, is to provide advanced education in the field of nuclear engineering technology to fill predicted needs for nuclear engineering technicians and other engineering personnel. For additional information about this course, circle No. 349 page 7-8. *CREI Atomics, Inc.*

Magnesium for ductile iron . . . specifications for magnesium-ferrosilicon, said to be a low-cost source, offered in 4-p booklet. Also lists specifications for post-inoculation alloys and describes how magnesium makes iron ductile. *Electro Metallurgical Co. Div. Union Carbide Corp.*
Circle No. 350, Page 7-8

Bentonite testing . . . discussed in 4-p bulletin. Includes photographs and graphs plus testing formulae, technical requirements and apparatus for the tests. Covers specifications for western bentonite used either as binder in core and mold sand or in preparation of core and mold washes in steel foundries. *Soiltest, Inc.*
Circle No. 351, Page 7-8

Investment-cast properties . . . of eight stainless and four low-alloy steels offered in 40-p booklet. Lists chemical compositions, applicable A.M.S. specifications and mechanical properties. Properties of heat-treated material are given for the hardenable grades of stainless steel and for the low-alloy steels. *Haynes Stellite Co., Div. Union Carbide Corp.*
Circle No. 352, Page 7-8

Cobalt superalloys . . . machining data and operating instructions given for 22 superalloys and three metal-glass sealing alloys. Discusses drilling, turning, facing, milling, broaching, reaming, shaping, tapping, cutoff and unusual machining methods of superalloys. *Cobalt Information Center.*
Circle No. 353, Page 7-8

Plastic processes . . . as well as metal processes in die casting, stamping, precision machine parts, metal forming, plastic molding, welding, assembly and die making are thoroughly covered in folder. *Ainsworth-Precision Castings Co.*
Circle No. 354, Page 7-8

Vibrating feeders . . . air-operated, covered in bulletin which contains photos and data on eight feeders. Includes 14 questions to answer and send to the company enabling them to recommend a feeder design to solve specific problems. *Cleveland Vibrator Co.*
Circle No. 355, Page 7-8

Ovens, dryers and heaters . . . used to produce engineered atmospheres described in 8-p booklet. Photographs illustrate foundry operations of baking cores and curing plastics. Includes information on indirect oil or gas fired heaters, shell-type direct air heater, tubular type indirect-air heater and high pressure hot water heating system. *J. O. Ross Engineering Div. Midland-Ross Corp.*
Circle No. 356, Page 7-8

Nickel bronze castings . . . melting and molding practice described in 4-p booklet. Practice said to produce sound structural and pressure-tight castings. Mechanical properties developed and tabulated. *International Nickel Co.*
Circle No. 357, Page 7-8

Plant facilities . . . shown in illustrated booklet. "Tour" of new 27,000 sq ft plant leads reader through 16-p booklet, starting in tool and die shop and ending in inspection department. *National Precision Casting Corp.*
Circle No. 358, Page 7-8

Materials handling problems . . . and how they were solved in various industries are offered in 16-p magazine. Illustrated stories take reader through plants from receiving to shipping. This is the spring issue of publication. *Lewis-Shepard Products, Inc.*
Circle No. 359, Page 7-8

Valve catalog . . . is a condensation, 20 pp, of company's 1958 catalog. Designed as quick reference and for the introduction of small industry to air power. Valves listed by function. Presents fundamentals of pneumatics and various applications of compressed air. *Ross Operating Valve Co.*
Circle No. 360, Page 7-8

Materials handling . . . side-loading unit featured in 8-p bulletin. Unit performs operations of stacking like fork truck, carrying like platform truck and delivering like road truck. Illustrated to show the complete plant and industrial operations. *Baker Industrial Trucks Div. Otis Elevator Co.*
Circle No. 361, Page 7-8

Thermocouples and pyrometers . . . for industrial purposes requiring high manufacturing, smelting and refining, heat treating and foundry operations, described in catalog. Outlines company's special order engineering service for the design of units to meet

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Circle No. 268, Page 7-8

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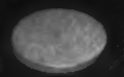
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Circle No. 269, Page 7-8

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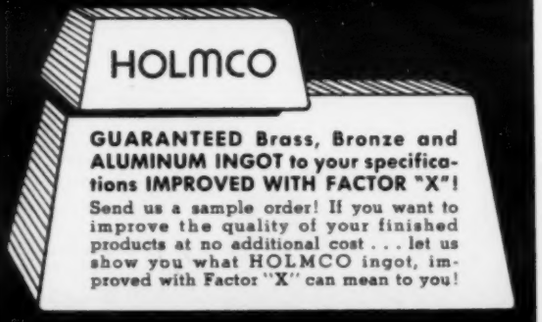

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Circle No. 270, Page 7-8

specific heat-measuring problems. *Raymond F. McHugh & Son.*
Circle No. 362, Page 7-8

Exothermic products . . . discussed in 8-p booklet said to present liquidizers and fluxes for all metals and alloys. Descriptions, directions, advantages and results of products included. *Pittsburgh Metals Purifying Co.*
Circle No. 363, Page 7-8

Filing equipment . . . for vertical filing of blueprints, maps, drawings and large sheets presented in illustrated, 11-p, booklet. Specifications of each unit offered as well as features pointed out in line drawings. *Plan Hold Corp.*
Circle No. 364, Page 7-8

Corrosion resistant . . . castings which reportedly resist high temperature corrosion and abrasion are discussed in well-illustrated booklet. Temperature properties, composition and typical uses of the alloy castings are included. *Blaw-Knox Co.*
Circle No. 365, Page 7-8

free films

■ **Motion pictures and other visual aids based on foundry processes and supplies are also yours *for the asking.* These films are suggested for formal or informal training groups. The owners of films in this column will send booking request forms to MODERN CASTINGS readers who circle the appropriate number on the Reader Service card (page 7-8).**

CO_2 Process in the Foundry . . . 16 mm, color, sound, 35 min. Film shows how the CO_2 Process is applied in the foundry. *Delhi Foundry Sand Co.*
Circle No. 366, Page 7-8

Tooling the Band Saw for Production . . . 16 mm, color, sound, 10 min. Describes versatility of band saw in removal of metal. Shows how machines provide new concept to machining operations requiring shaping, slotting, splitting or facing. *DoAll Co.*
Circle No. 367, Page 7-8

Grinding Wheels and Their Application . . . 16 mm, sound, color, 24 min. Portrays where and how grinding wheels are used in industry. Also discusses factors that make up a grinding wheel. *Simonds Abrasive Co.*
Circle No. 368, Page 7-8

Advanced Welding Techniques . . . 16 mm, color, sound, 10 min. Film shows importance of using correct electrode for specific welding jobs. Shows how right electrode results in faster and easier welding at lowest cost. *Westinghouse Electric Corp.*
Circle No. 369, Page 7-8

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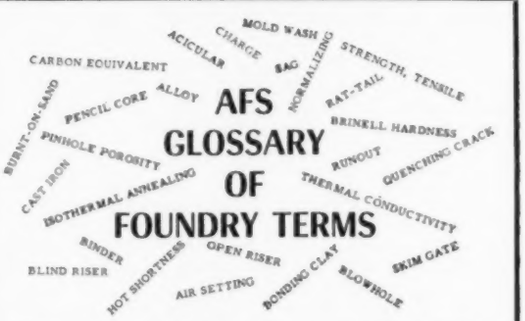
Circle No. 271, Page 7-8



Including almost 2000 terms, this book is intended to help standardize the meanings of foundry terms throughout the metal castings industry. In its preparation, reference was made to many presently existing glossaries and dictionaries of scientific and engineering terms. IT IS THE MOST COMPLETE WORK OF ITS KIND and should be at the finger-tips of every member of the metal castings industry. (80 pp. 6 x 9 Paper Bound.)

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obituaries

Hamilton Garnsey, Jr., 56, vice-president and general manager, Goulds Pumps, Inc., Seneca Falls, N. Y. died recently. He joined the organization in 1923, serving as works manager for many years, a director since 1932 and vice-president since 1938. Garnsey was a member, AFS Central New York Chapter.

James E. Eppley, charter member and Past President of the AFS Southern California Chapter, died recently.

E. N. Wheeler, 48, metallurgist, Belle City Malleable Iron, Racine Steel Castings Co., Racine, Wis. died recently. He had been with Belle City Malleable Iron for 30 years.

J. A. Obermaier, 68, president, Illinois Testing Laboratories, Inc., Chicago, died. He was one of the pioneers in the development of temperature measuring instruments and held many patents in the instrument field.

Herbert Flint, 69, lifelong foundryman, died in Orrville, Ohio, recently. He was born in Blackburn, England and came to this country in 1909. Flint was one-time superintendent of the Quality Castings Co., and a partner in the Berted Foundry, Columbiana, Ohio, and vice-president of the State Foundry Co., Akron, Ohio.

Alexander S. Wright, sales representative, Springfield Facing Co., Watertown, Mass., died recently. He was a member and past president, AFS New England Chapter.

Albano Schmidt, founder and president, Fundicao Tupy S.A., Santa Catarina, Brazil, died recently. He was a member AFS Mexico Chapter.

Daniel E. MacLean, 63, vice-president, Lava Crucible Refractories Co., Pittsburgh, Pa. died recently. MacLean has been with the company since 1926 and was a member of the AFS Pittsburgh Chapter.

F. G. Nichols, general foreman, Railroad Products Div., American Brake Shoe Co., St. Louis, Mo., died recently. Nichols was a member, AFS St. Louis District Chapter.

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Circle No. 273, Page 7-8

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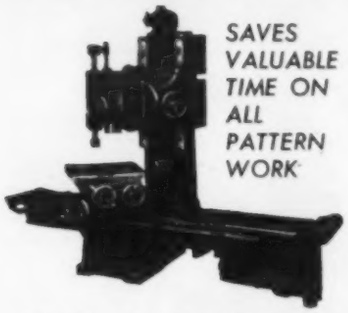

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Circle No. 275, Page 7-8

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Circle No. 276, Page 7-8

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let's get personal

Sam Ashwood . . . has been named vice-president, Target Northern Corp., Kansas City, Mo. He will devote full time to the distribution of Target's masonry saws, concrete saws, abrasive, safety and diamond blades.

Emil J. Romans . . . was recently appointed foundry superintendent, National Malleable and Steel Castings Co., Cleveland, where he began 25 years ago as a checker. He gained experience in all foundry operations before he became supervisor in charge of molders and labor. He replaces Frank Steigerwald who retired last month, after 40 years of service. Romans is a member of the Cleveland Technical Society council and is AFS Northeastern Ohio Chapter Chairman.

Carl E. Rowe . . . has been appointed president, Milwaukee Valve Co., Milwaukee, Wis. Rowe advanced in two years from assistant general manager to vice-president and general manager prior to his present position. He is a widely respected authority in the field of foundry operations. His present company manufactures a complete line of bronze and aluminum valves and allied products for the plumbing and heating industry and petroleum marketing industry.

Edward Hill . . . Corn Products Sales Co., New York, will serve customers in both Eastern and Southern Divisions and will continue to maintain his headquarters in Eastern Division as part of the company's expansion. **J. R. Belche, Jr.,** has been named to serve the foundry industry in the Southeast, working out of the Atlanta office. Both are technically trained men who will provide direct technical assistance to Corn Product's users.

James Patterson . . . is the new Philadelphia representative of National Engineering Co., Chicago, Ill. He was formerly with Simplicity Conveyor Co., Durand, Mich.

Bert Troy . . . is now vice-president of Pennsylvania Electric Steel Castings Co., Hamburg, Pa. Troy was the former Philadelphia representative for National Engineering Co., Chicago, Ill.

A. B. Penters will represent Archer-Daniels-Midland Co., Federal Foundry Supply Div., Cleveland, in serving foundries in the Western Michigan area. Penters has served in production, experimental and engineering capacities at Ferro Machine, Ford Motor Co., and White Motor Co.

E. B. James . . . has accepted a position as foundry process engineer and metallurgist, Clark Brothers Co., Chicago. He is a member AFS Chicago Chapter.

E. J. Romans

J. Patterson

A. B. Penters

classified advertising

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FOUNDRY METALLURGIST Experienced in electric furnace melting and laboratory technique. **ST. LOUIS STEEL CASTING INC., 100 Mott St., St. Louis 11, Mo.**

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MOLDING MACHINES WANTED One Milwaukee Jolt-Squeeze Stripper Model 216 also one Osborn Roto-Lift Model 3161. Address **Box E-35, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

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WANTED! BOUND VOLUMES OF TRANSACTIONS OF AFS. Arrangements to sell bound volumes of TRANSACTIONS of AFS, intact and in good condition, may be made through AFS Headquarters. Those who have no further use for any volumes of TRANSACTIONS on their bookshelves are requested to communicate with the **Book Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Illinois.**

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Indian Foundrymen Told to Improve Technical Training

■ Recent developments in foundry technology were discussed in a symposium held in Jamshedpur, India, in February. The symposium was organized by the National Metallurgical Laboratory, Jamshedpur, in collaboration with the Institute of Indian Foundrymen.

According to Dr. B. R. Nijhawan, Director of National Metallurgical Laboratory, "purpose of the symposium was to focus on latest developments in foundry technology and to study the scientific developments abroad in techniques of founding metals and alloys which could be successfully implemented in the Indian foundry industry."

Training Centers Needed

Sir J. J. Ghandy, Tata Industries Ltd., and chairman of the executive council, National Metallurgical Laboratory, presided. Speaking before the delegates, he said that the foundry industry in India needed immediate establishment of training centers, both at the University and trade levels, if it hopes to keep pace with development in other related industries. He stressed need for proper training of personnel, both technical and managerial, and adoption of modern methods.

Scope of the symposium was as follows:

- raw materials for molds and cores;
- equipment and methods for materials handling;
- modern innovations in foundry technology (CO_2 process, shell molding);
- new developments in melting, including casting techniques and latest equipment;
- recent developments in the founding of ferrous and non-ferrous metals and alloys;
- the position of the foundry industry in India relative to the country's second Five Year Plan;
- foundry mechanization and layout;
- and foundry management.

American Papers

AFS immediate past-president, H. W. Dietert, Harry W. Dietert Co., Detroit, authored one of the technical papers read at the symposium, entitled, "Casting Quality Control Dilatometer."

Other papers written by Americans and presented before the symposium are as follows:

"*Some Problems in Shell Molding; the Possibilities of Shell Cores,*" A. Woods, Shallway International Corp., Palo Alto, Calif.; "*The Bonding Mechanism in Foundry Sand Mixtures,*" Dr. D. C. Williams, Ohio State University, Columbus, Ohio; and "*Foundry Mechanization,*" C. V. Nass, Beardsley & Piper, Chicago.

Millions Heard About AFS Foundry Show Over Radio

■ The AFS sponsored Casting Congress and Foundry Show was well publicized over the nation's air waves. In addition to the mention given the Show in Alex Dreier's coast to coast salute to the metal casting industry, International Nickel Co., New York, spotlighted the Show and its exhibit on all the company's 31 radio news broadcasts throughout the country.

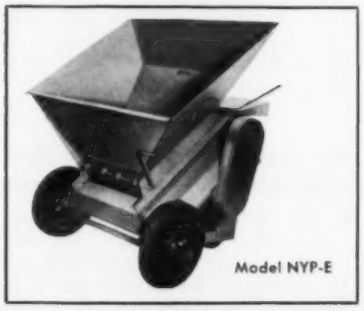
Inco's broadcast time is selected to coincide with the highest percentage of male listeners, 7:00-8:00 am and 6:00-7:00 pm. Every broadcast mentions the distributor and local address as a source of information and supply for Inco nickel and nickel alloys in addition to offering the added incentive of Inco technical service.

AERATE AND FLUFF AT MOLDING STATION FOR MAXIMUM BENEFITS

To take full advantage of the economies of central sand conditioning, highly mechanized foundries usually find it necessary to sacrifice other elements. Some of these are permeability, flowability and cooled sand.

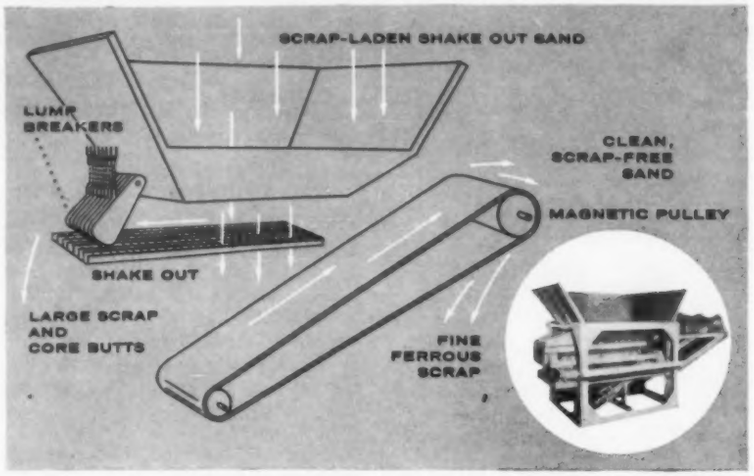
To produce the best possible molds, sand should be aerated and fluffed as the final operation, before it is used. More and more, foundries with central systems are turning to Royer to help improve their sand's properties.

Thousands of foundries have increased the permeability of their molding sand 10 to 20 points by aerating at the molding station with a Royer Separator and Blender, like the Model NYP-E shown here. Besides eliminating the problems of packed sand, they gain the advantages of better flowability and cooled sand. Royerizing reduces new sand requirements and often eliminates entirely the need for facing sand. Castings have smoother finishes, too, reducing grinding and cleaning costs.



Royer Sand Separators and Blenders are available in sizes to fit any foundry need. This Model NYP-E handles the charge of a front-end loader. Other models are available with capacities as low as seven tons per hour.

Two bulletins describe the Royer line of Sand Separators and Blenders. Bulletin SS-54 covers machines from 7 to 60 tons per hour maximum capacities. Bulletin NY-54 describes the series engineered for high capacity sand handling systems. Write for your copy today.



Sand Contamination Drains Your Profits

Periodic business recessions in the foundry industry point up the need to eliminate waste and excessive hand labor—or sacrifice profits. In one area of foundry operation—sand contamination — important strides have been made in stopping the profit drainage.

Tramp iron damage usually occurs at the muller, conveyor belts, aerator or patterns. Patterns faced with contaminated sand produce poor casting finishes and high scrap loss. Probably the most efficient and economical way to remove contamination and produce clean sand is with a Royer Scrap Control Unit.

Referring to the drawing, shake out sand from the molding floor is dumped by front-end loader into the receiving hopper. Large scrap is riddled out by the Shake-Out and discharged at convenient wheelbarrow height for collection and removal.

Ferrous scrap small enough to pass through the grid openings of the Shake-Out is separated from the sand by a magnetic pulley at the upper end of the conveyor belt. Depending upon the degree of mechanization you employ, clean sand discharge may be made to a skip hoist feeding a muller, conveyor belt, or into the hopper of a Stationary Royer Separator and Blender for cooling, aeration and blending. We recommend discharge onto a heap for transporting by front-end loader to a Portable Royer Separator and Blender at the molding station for cooling, aerating and fluffing.

If tramp iron is the cause of any of your profit loss, we invite you to discuss your problem with the foundry-wise Royer agent serving your territory. He'll explain how a Royer Scrap Control Unit can pay for itself in less than two years, stop your profit drainage and improve the quality of your castings.

Your first step in stopping profit drainage caused by sand contamination is to mail the coupon for our latest Scrap Control Bulletin. We'll send it without obligation—plus the name of the agent who serves you.

ROYER FOUNDRY & MACHINE CO.

ROYER 155 PRINGLE STREET KINGSTON, PENNA.

Sand Contamination is cutting into our profits.
Please rush me your Scrap Control Bulletin.

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International Foundry Conference to Feature Service.

■ With "Foundry at the service of man," as its theme, the 25th International Foundry Conference will convene in Brussels and Liege, Belgium, Sept. 29-Oct. 4, under the auspices of the Technical Foundry Association of Belgium.

The spirit of the conference is commensurate with the general theme of the Brussels' 1958 Universal and International Exhibition—*reviewing progress toward a more human world*. Conferees will be offered free tickets to the Exhibition valid throughout the Foundry Congress.

Exchange Papers

Exchange papers will be presented during four technical sessions. The first session will cover automation and professional education. Scientific problems will comprise subject material for the second session; direction and organization of scientific research and reports on original research work will be discussed.

The third technical session will cover technical problems concerning cooperation between foundrymen and designers. In addition, papers relating to attainment and application of properties required in to-day's castings will be presented. The final technical session will feature technological problems in the foundry.

Representing the United States will be H. F. Taylor and M. C. Flemings, Jr., Massachusetts Institute of Technology, Cambridge, Mass. Their paper is entitled, "*Adapting Theory to Practice in Making High Strength Light Metal Sand Castings.*"

The calendar of events will include visits to plants and laboratories, evening parties and a tour of the International Exhibition. A program has been organized for the ladies, allowing ample shopping or browsing time in either Brussels or Liege.

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1 Vacuum Casting

Electric furnace alloy steel, shotted in revolutionary new vacuum chamber for greater density, eliminating the voids and defects encountered in conventional steel shot. Gives you a fatigue resisting shot of much longer wear life.

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Nothing like it in the industry. Uniform heating of every particle, in zero oxygen atmosphere. For the first time . . . ball bearing heat treating quality in a tonnage product . . . gives you uniform hardness and longer life.

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MAGNESIUM ALLOYS	for all types of castings
MAGNESIUM ANODES	for cathodic protection
ZINC ALLOYS	for die castings and metal forming dies

* Furnished in ingot, shot, piglet, grained and special forms.
** Furnished in ingot and shot.

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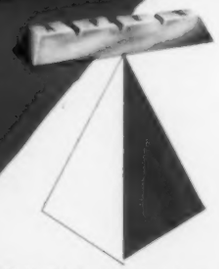

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A practical, working knowledge of your problems . . . a superior product to meet them. These are the standards by which Apex Ingot is made . . . the reason why Foundrymen and Die Casters everywhere say, "It's best in every test from Ingot to Casting!"

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SPRINGFIELD, OREGON (NATIONAL METALLURGICAL CORP.)

modern castings

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